

Practical Bee Breeding

A. Gilman



**PRACTICAL
BEE-BREEDING**

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PRACTICAL BEE-BREEDING

by
A. GILMAN



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by

A. Gilman

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Read not to contradict and confute, nor to believe and take for granted, nor to find talk and discourse; but to weigh and consider.—Bacon.

AUTHOR'S PREFACE

This book, being the result of many years independent thinking and practice on the part of the author, is written with the object of assisting the apiarist to a fuller understanding of his undertaking, and to offer systems and appliances that will further aid in the production of first class stock with a minimum of expense and effort.

The author has no pretensions to either science or literary ability. He writes as a plain and practical man for other practical men, who have no desire to lose themselves in the intricacies of scientific literature, which is mostly in a form that makes it of no use to the ordinary bee-keeper.

The author's best thanks are due to Mr. L. Illingworth, for some helpful suggestions, and for his consenting to write the Introduction.

Although the book could have been considerably enlarged, it was thought advisable to keep it within the smallest possible compass.



INTRODUCTION

SINCE the publication of Sladen's *Queen Rearing in England*, some twenty years ago, no work on the breeding of bees has appeared in this country. British bee-keepers have turned their attention to other things, and seem to have neglected this important subject. Such new books as have appeared, as far as I am aware, are either general treatises, or deal with some other special branch of the craft.

In the meantime, other countries have not been idle. Much interest has been aroused in Switzerland, and Dr. Kramer's *Rassenzucht* has lately been revised and brought up to date. Perret-Maisonneuve's book has appeared in France, and still more recently, Jay Smith's *Queen Rearing Simplified* has given us an account of the latest developments of the Doolittle System in the United States of America.

Mr. Gilman's *Practical Bee-Breeding* adequately fills the gap in our bee literature. His book is no mere compilation from other people's works, nor is it limited to *Queen Rearing*. It

is an entirely new work on a much wider subject—Bee-Breeding—and is written by an original thinker and practical bee-keeper.

Most writers on this subject agree in thinking that we ought to apply to bee-breeding the principles that have been followed with so much success by farm-stock and plant breeders, but the attempt to do so has not resulted in any marked improvement in the bee corresponding to what has been achieved by workers in these other departments. This is not, as the author of this book clearly shows, because the principles of animal and plant are not applicable to bees, but because the fact of parthenogenesis introduces a complication which breeders of other stock do not have to reckon with, and necessitates certain modifications in the practical application of those principles to bee-breeding if the best results are to be obtained. No previous writer seems to have grasped the full significance of parthenogenesis for the breeder of bees, and this is where the present book breaks really new ground. The author not only states the modifications in general breeding practice necessitated by it, but clearly explains the reason for them.

The book abounds in valuable material both theoretical and practical, but the chapters on Breeding through the Drone, Making a Strain,

and Line-Breeding (with its method of starting a "line" with three queens, and the admirable chart which accompanies it), are specially deserving of mention. The author has also invented a new method of Queen Introduction, and his Group System is calculated to simplify the work of the large breeder.

Whether all larvae are fed alike for the first three days or not, is a question not at all easy to decide. For the present I cannot accept the author's views on this matter though he brings forward a considerable amount of evidence in support of them. I do not feel the question can be finally settled without further careful scientific research, and until this has been carried out I prefer to keep an open mind both on this, and on the important practical question out of it, whether equally good queens can be reared from grafted larvae as from eggs.

I welcome this new book and heartily recommend it to all progressive bee-keepers. The author is to be congratulated on his achievement, and our thanks are due to him for passing on to us the fruit of his labours. May it help to stimulate a new interest in Bee-Breeding in this country, and may the time be not far distant when the attempt to improve the bee is not left to the professional specialist alone, or to an enthusiastic

amateur here and there, but when intelligent bee-keepers everywhere work together in friendly rivalry, not only to produce better honey for the show bench, but to breed better bees.

L. ILLINGWORTH.

FOXTON, CAMBRIDGESHIRE,

October 28th, 1927.

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PRACTICAL BEE-BREEDING

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CHAPTER I

THE HIVE

The Inmates

The inmates of the bee-hives are of three kinds: queen, drone and worker. The queen and drone are the two reproductive castes; the worker is a neuter.

Each of these castes has a function to perform peculiar to itself, and never does the function of one caste overlap that of another. Although the duties of each caste are clearly defined, the continuation and prosperity of the colony depend entirely on the combined operation of the functions of all three castes.

The Queen

The queen is the only perfect female in the hive, and her sole function is the laying of eggs. She has no concern with the after care of her eggs

or the progeny resulting therefrom. That duty devolves upon her non-reproductive daughters—the workers.

The queen differs from the other castes in size, shape and colour, being longer and of more slender structure.

By any untoward occurrence that deprives a colony of its queen, the bees are thrown into a state of great excitement, and they run everywhere, both inside and outside the hive, in the endeavour to trace and find their queen-mother.

The bees will maintain this search for many hours, eventually to be convinced that the old queen has departed for ever. They then proceed to rear other queens from larvae hatched from eggs laid by their lost queen.

Under normal conditions the bees will raise queens when preparing to swarm. The cells are started and into them the queen lays the eggs that will eventually be transformed into queens, one of which will ultimately head the colony after the departure of the swarm with the old queen. As the queen larvae develop, the cells are built in a peculiar manner to accommodate their royal occupants. The cells of both drone and worker larvae are almost horizontal with the mouth of the cell slightly inclined upwards, which causes those two castes to develop while in a horizontal posi-

tion. The queen cell, however, is built to assume a pendulous position, with the result that the queen pupa develops in the cell with her head downwards.

The bees also raise other queens from eggs laid by the old queen when the latter is found to be approaching the end of her usefulness in egg-production. The young queens are raised before the actual demise of the old queen, who is frequently found functioning in the hive at the same time as one of her daughters. Eventually the old queen disappears, and the younger one is left in sole and undisputed possession of the place of royalty.

Should there, by any means, be an absence of drones when the young queen is reared, she could not become fertilised, and would in consequence become incapable of producing any caste other than the drone.

There seems to be a limit to the period during which the young queen can be fertilised. After that period, which is usually twenty-one days, although some reports show that it may be extended, the queen cannot mate and, therefore, can never function as a perfect female. Her progeny consist of nothing but drones, which are produced from unfertilised eggs and she becomes known as a "drone-breeder." Her

value is nil, and her place is soon filled by the apiarist with another and normal queen.

Up till quite recently it was universally accepted that a queen mated only once in her life. Evidence is now forthcoming that some queens mate at least twice. As to the intervals between the first and second mating, there is no reliable evidence, but what there is tends to show that the period varies in length.

A moderately fecund queen will lay about three thousand eggs in one day. As eggs must come from food in excess of that required by the creature for its own sustenance, it is obvious that the feeding of the queen must be different from that of the females of other live stock of an oviparous nature. That feeding is carried out by the nurse bees, who supply the queen with a glandular secretion of a rich nature derived from themselves.

The queen possesses a sting, but whereas that of the worker is straight, that of the queen is curved. It is taught that the queen never uses her sting except against a rival of her own sex. We believe that to be an error. There must be some reason for the sting being curved, and it is most probable that it takes that form to enable the queen to use the sting to release herself from the embraces of the drone when mating. Con-

sidering what takes place when mating has been accomplished, the separation of the two castes must be painful to the drone, who probably needs some forcible persuasion to make him release his mate.

The Drone

The drones are the male bees and have as their sole function the fertilising of the young queens. Having no sting, they are quite defenceless. They are incapable of working to help in the support of the colony, since they have no suitable proboscis for honey gathering, no pollen baskets on their legs with which to carry pollen, and no wax pockets on their abdomens for secreting wax. They are, therefore, absolutely dependent on the workers for their support.

The drones make their appearance well before the swarming season, but the actual time is governed by the forwardness or backwardness of the season, by the strength of the colony, by the amount of food in possession of the stock, and by the strain of bees; some bees more readily producing drones than other strains.

Mating

The mating of the queen with the drone takes place in the air. This must be so since the sexual

organ of the drone cannot be brought to function without the filling of all the tracheæ with air. This can only take place during rapid flight.

The fertilisation of the queen by the drone results in his death. When the act of mating has been accomplished, the organ of the drone is torn from him and the queen returns to the hive with his organ attached to her abdomen. After a time the drone's organ withers and is removed from the queen with the assistance of some of the workers.

At the end of the season when the honey-flow has finally ceased, the drones remaining are no longer needed and they must be cleared from the hive, since they would otherwise consume the stores to no purpose. To get rid of them, the workers withhold food and drive the drones from the hive to perish.

The drone, as is well known, is produced parthenogenetically. This peculiar method of reproduction, operating with other creatures besides the bee, must have some necessity in the provision of nature.

The fact that mating takes place in the air has led to the belief that the object is to avoid inbreeding. To a certain extent that is true. If a drone were capable of fertilising the young queen

in the hive the stock would eventually deteriorate, since no outside blood would be introduced to counteract consanguinity. But in the very nature of the bee and its method of fecundation, it must arise at times that a queen should mate with a drone from her own stock. Here then we find the necessity of parthenogenesis, which causes a difference of fifty per cent in the blood of a virgin and that of a drone from the same queen-mother; a margin sufficiently wide to counteract any deterioration likely to arise by the occasional mating of the two castes from the same stock.

It has also been thought that fecundation in the air permits or provides for the crossing of the breed, which, by many, is considered necessary for the continuation of the vitality of the colony. But crossing can only take place where there are two or more distinct races of the bee. A female is not crossed by mating to a male of her own race.

Therefore, we believe that wrong deductions have been made as to the reason for mating taking place on the wing. Probably it may be to avoid the perpetual mating of drone and queen from the same hive. But that does not show the necessity for crossing. In fact with some of the most virile races of the bee, such crossing has

not and could not have taken place for many centuries, owing to the absence of any other race of bee.

The bee's peculiar method of mating we believe to be due to a necessity to prevent the reproductive castes of the same hive *continuously* mating; but the mating of queens with drones of the same strain and race is compatible with the production of sound stock, and further, is not only the true method, but the one that is endorsed by nature.

The belief in the necessity of the queen being crossed when mating, has undoubtedly led to extremes in that matter. At the present time, especially in this country, no breeding is considered right that does not include a considerable amount of out-crossing. Occasionally out-crossing may be true and necessary for other live stocks, which are not the subject of parthenogenesis, but we do not believe it applies to the bee. If it does, how can we account for the virility of certain races of the bee that have not been out-crossed for centuries?

We believe that environment is all-sufficient to change the blood of a stock so that no deterioration will result, when individuals of the same strain, but from different environments, are mated together. Thus a poultry breeder who

knows his business will endeavour to obtain the same blood as his own, but of that reared in a different locality. In the latter case the birds would have been subjected, in addition to the particular influences due to different surroundings, to different treatment regarding food and housing, all of which would have some influence in altering the relative value of the blood.

In the apiary, the environment of one hive is not that of another, either internally or externally. That there is a difference in the external environment of two hives in the same apiary may be questioned. But all stocks do not gather nectar and pollen from the same sources, and those products coming from different plants must necessarily vary in composition.

Since, therefore, the bee is always consuming for its own sustenance some of the nectar and pollen it gathers, the variation in the composition of its food must have some influence in altering the composition of its blood, exactly as is the case with poultry, subjected to different treatment in different localities. It is because the bee covers, in comparison with other kinds of live-stock, such a huge territory, that we can rightly assume each hive as being in an environment peculiar to itself, and one quite different from that of any other hive.

The Worker

The worker-bees, although smaller in size than either the queen or drone, constitute the much greater portion of the colony. They are undeveloped females and therefore are neuter as regards sex.

Their duties in the hive are many and various. Upon them devolves the welfare of the entire colony, the various duties being carried out by different ages. Some search the flowers in the surrounding country for nectar and pollen which in combination form the food of the bee. Some gather propolis with which to fill up all cracks and crevices in their home and so protect themselves against the weather. Some ventilate the hive and remove dead bees and other debris. Some secrete the wax made in their own bodies for building the comb, the cells of which act as both cradles for the larvae and store cupboards for the honey and pollen, while others carry water which is required in large quantities in the production of brood.

Although the worker has no part in the production of progeny, it has an important office of a dual nature in caring for the eggs and their resulting larvae after hatching. That office consists of nursing and brooding. The younger workers, termed "nurse-bees," prepare food for the larvae

from a secretion from certain glands in their heads, and distribute the food as required by the larvae. They also maintain the temperature of the hive necessary for the proper development of the larvae to maturity.

The worker energetically defends its home and stores of food, for which purpose it is provided with a sting, which it never fails to use when occasion demands.

The period of the life of a worker is comparatively short, but its length greatly depends upon the amount of work performed. It is usually computed to be from six to eight weeks in the honey-gathering season, at which time the work is severe; but its life is much longer at other times like that of winter, when very little activity takes place. The same statement applies to the food-secreting glands of the nurse-bees. Those glands also have a certain length of life, which depends upon the amount of function they are called upon to perform.

Although we said that a function of one caste never overlaps that of another, occasionally there is an attempt by one caste to function for another. The attempt is actuated by necessity.

When a stock has been queenless for a considerable period, some of the workers will endeavour to function for the queen by pro-

ducing eggs, instinct informing them of the vital necessity for a continuation in the production of progeny. But this attempt is quite futile, since the laying worker, like the nonfecundated queen, can lay none but infertile eggs, and therefore can produce no caste other than the drone. The drone, however, from such parents is undersized and believed to be of no breeding value. In such circumstances the colony is ultimately doomed to perish unless of course rescued by the apiarist—but if the queenlessness has been of very long duration, the stock is not worth the trouble of saving.

The possibility of a neuter or worker-bee becoming fertile is an interesting fact: more so, since the worker is incapable of fecundation. Apparently, some workers retain a portion of their ovaries in a rudimentary form, which only needs certain conditions, such as queenlessness, an absence of worker-eggs or larvae, some food, and a sufficient number of nurse-bees, to cause their ovaries to develop sufficiently to permit the formation of eggs. These eggs, however, always produce the drones.

Another interesting point is that infertile eggs should hatch at all. This is not peculiar to the bee, there being many instances among insects of the production of offspring without the mother

having been fecundated. This is known as “virgin production” or “parthenogenesis.” Only one caste of the bee is subject to parthenogenesis—the drone.

The transformation of the bee from the egg to the perfect insect is divided into periods which, however, vary with weather conditions and the amount of food available. The following table shows the normal periods:—

	Queen. Days.	Drone. Days.	Worker. Days.
Period of incubation of eggs....	3	3	3
Growth of the feeding larvae....	5	6½	5
Spinning of cocoon by larvae....	1	2	2
Period of rest.....	2	3½	3
Transformation into pupa.....	1	1	1
Period in pupa stage.....	3	8	7
—	—	—	—
Average total period of transformation from egg to perfect insect	15	24	21
—	—	—	—

CHAPTER II

SOME RACES OF THE HONEY-BEE

Apis Mellifica

While there are several species of the honey-bee, there is only one—*Apis Mellifica*—with which, because of its economic importance, we are here concerned. It is indigenous to the three continents of Europe, Asia and Africa. Of that species there are again several varieties, each having characteristics developed probably by environment. Some varieties have been domesticated and the most important are the following:—

The British Black

This is a black bee with faint bands of white hair on the abdominal segments. It is a moot point whether this bee should be written of in the past or present tense. If this bee has been allowed to die out, it is a matter that reflects no credit on British Apiculture. Prior to the ad-

vent of the I.O.W. disease, it had been condemned for being insufficiently prolific and for its rather excitable behaviour when under manipulation. While, it is granted, the fecundity of this race was below that of other races, it by no means follows that that was a disqualification. From whom came the condemnation on account of its want of prolificness? Not from the average bee-keeper, who was quite content with the bee in that respect. The climate of Britain is not such as to demand a very prolific bee; what is necessary being a bee that builds up early in the season; and this trait we had in the old British Black.

If instead of importing bees of almost every race under the sun, we had endeavoured to improve the native bee, it is probable that we should never have had the sad and expensive experience of the I.O.W. disease. The British Black had characteristics that were eminently suitable to the changeable climate of the country. It never bred out of season, and was very conservative in the use of its stores, always looking forward to the bad seasons which are more frequent than good ones. That it had faults is admitted. But so had other domestic stock, whose faults in the hands of capable British stock-breeders were eliminated: their good points developed and

their economic value much increased. The same results could have been achieved in the case of the native bee. It was hardy; wintered well; did not swarm excessively; withstood dampness and various epidemics; was docile when pure; industrious and strong on the wing, and its sections were unsurpassable.

When the disease known as I.O.W. visited this country, the bees in this country were found to be very susceptible, and the British Black was condemned as being more susceptible to that disease than any other race.

The fact, however, that fresh importations of bees fell victims almost immediately to that disease, should make us pause in the condemnation of the native. That there should have been a greater number of British Black stocks affected is only to be expected, since stocks of that race were in a great majority. But apart from these considerations, it is to be regretted that after the abatement of that scourge no definite action was taken to discover whether any pure British Blacks were still in existence: for had there been any, their existence would have been conclusive evidence of the possession of both a robust constitution and a high degree of immunity. Such a bee would have been invaluable and worthy of retention.

The Carniolan Bee

This is another black bee with the white bands much more pronounced than they are in the British Black. It is also a larger bee and very good tempered. Its swarming propensity is such, however, as considerably to reduce its value. It is an excellent builder of comb, and leaves the cappings pure white. As regards surplus gathering, the author must confess to never having done any good with them. There is always a great display of energy at the entrance to the hive; which leads the apiarist new to their peculiarities, to build visions of huge surplus, which seldom materialises. A cross with the male Carniolan and a queen of another race brings very little improvement on the pure race, but a cross in the opposite way results in a really good bee.

The Caucasian Bee

This is very similar in appearance to the last named bee, but in the author's opinion much superior. It is as gentle as the latter, but has failed in public estimation on account of the large amount of propolis it gathers and uses. There is, however, one strain that has had this fault bred out.

The Dutch Bee

This bee much resembles the British Black, but

is, if anything, rather smaller. It is notorious as a swarmer; but there are strains that are no worse in this characteristic than many other races. It also seems amenable to swarm control and in this matter is preferable to the Carniolan. It is a fine builder of comb, and its cappings equal those of any bee in existence.

The Italian Bee

This bee, as its name denotes, originally came from Italy. It is of the yellow race and is conspicuous by having bands of yellow which vary in colour from orange to bright golden. It is good tempered and quiet under manipulation. It is prolific—a characteristic that has been pushed by most breeders. Another characteristic that has received much attention from breeders is the size of the queens, those of some strains being very large. The queens also vary considerably in colour from a dark to a lighter yellow.

In our experience this race seems to be more suitable for a warm climate, or one having a long summer season. In a cold climate it is late getting to work at the beginning of the season, but as the season advances and the weather becomes warmer, it usually makes up for lost time.

This race has been so widely disseminated throughout the world that there is scarcely a

country, with a moderately warm climate, that does not possess Italians. But like all popular varieties of live-stock there is a vast difference between strains—some are quite inferior while other strains are altogether superior, to the general.

While this bee is endorsed by many experienced apiarists who will keep no other race, it has a fault that few have observed. The failure to discover this fault is, we believe, due to the absence of Black bees which are necessary for the purpose of discovery. The fault to which we refer and which is made conspicuous only where Black bees are in the same apiary with Italians is their thieving propensity with its possible and probable consequence. In connection with this trait of the Italian bee, the author cannot do better than to give his experience in two instances that occurred within recent years. When he returned to this country the first bees he obtained were Italians. That was only natural, since he had imported this bee direct from Italy prior to taking up his residence abroad, and also had had them when across the water. Hearing and reading, however, many adverse criticisms of the Italian bee, he decided to test it against some Blacks. Of these latter he procured several races, the number in the first year being twenty-two stocks,

which came along during the month of May. Well, within three weeks, no less than seventeen stocks of the Blacks had Italian lodgers, not only from those stocks within the apiary, but also from other Italian stocks, both pure and hybrid, belonging to other apiaries. No doubt many of the same sort of travellers would have been in the remaining five hives, had not the inmates been Caucasians and Carniolans. In no Italian stock in the apiary was there a single Black bee; either they stayed right at home, or else the Italian would not permit their entry. That one occurrence alone was sufficient to prove the Italian bee to be absolutely dangerous. What would have occurred if one of the Italian stocks had been heavily diseased? The disease would most certainly have been scattered throughout the apiary and probably the whole apiary wiped out.

On another occasion a small piece of comb containing a very small quantity of honey had been built beneath a shallow frame feeder that had been used in a stock on deep frames. This piece of comb was put on the bench when the writer was called away for a few minutes. When he returned there were several hundred Italian bees, either on the piece of comb or on the window, but not a single Black. The next day the Italians returned, but finding nothing to steal, soon made

for the window again, and among them on that day was just one solitary Black bee.

From this most undesirable trait of the Italian bee, we get some explanation of the spread of foul brood. It is a serious and urgent matter that requires the fullest investigation, for no live-stock industry can for long withstand a devastating disease, and a stock whose characteristic is to disseminate that disease.

The Cyprian Bee

This is another of the yellow races. The queens are most prolific and a peculiarity of this race is the very large number of queen-cells raised when preparing to swarm, sometimes as many as a hundred being built. The bees themselves are rather warm in temper, but according to a prominent breeder, in its homeland, this propensity has been altered considerably for the better—a good bee for extracted honey, but quite outside the pale for comb honey.

CHAPTER III

DESIRABLE CHARACTERISTICS IN THE HONEY-BEE

Relative Value

In dealing with the most desirable characteristics of the bee, we think it will be agreed that any reference to their relative value is quite out of the question, since in whatever order of importance they were placed, there would certainly be some difference of opinion. Therefore, we leave every reader at liberty to place them in the order he thinks their importance demands.

There is, however, one characteristic that, by its very nature, must be placed at the head, since on it depends the economic result that constitutes the ultimate object of the bee-keeper. The quality to which we refer is stamina.

Stamina

Stamina is by far the most important quality that a creature of economic value to man can possess. It is the very foundation of success in every direction, and a quality that should be possessed by every kind of live-stock, whether it is

to be expressed in physical effort as in the horse, or in the production of wealth from itself, such as milk from the cow or eggs from poultry.

Of the two kinds of live-stock, however, represented by action and production respectively, its possession is of more importance to the former than the latter.

The economic value of the honey-bee consists principally in the ability to work, and in consequence, the possession or otherwise of stamina becomes of the utmost importance.

Stamina, however, is a subject that seems to have been carefully avoided, which is not altogether surprising, since it is one of those subjects that are little understood. This may be attributed to the fact that there is no factor for stamina as there is for type, shape, and colour, neither is there anything on the surface to indicate whence stamina is derived.

While the subject of stamina has been very little discussed, many references have been made to its loss, and almost invariably that loss has been attributed to the use of immature drones.

Those, however, who postulate the loss of stamina to that cause, declare in almost the same breath that the queen when on her mating flight is secured by the strongest drone!

Drones, however, are produced so far in ad-

vance of the time when they may be called upon to perform their life's function, and therefore have such ample time to reach maturity, that the mating of immatured drones is highly improbable.

Stamina, if inherited, can be carried only by what the parents produce—sperm or eggs. And since the sperm eventually reaches the germ within the egg, we should include the latter in our discussion.

We know from breeding other kinds of livestock, that it is possible to get weak progeny from parents of proven stamina. This indicates that stamina, unlike other factors that are transmitted by the parents, does not reside in the fertilised germ. But since every quality possessed by the progeny comes from the egg, we must look in the egg elsewhere than in the germ for the source of stamina.

The fact is that stamina is in proportion to the quality of the egg—or rather the yolk of the egg. To the young creature the vital part of the egg is the yolk, which constitutes its first and principal food, and should it not be of the right quality, there must result a loss of stamina in the creature.

With ordinary domestic stock, the fowl, for instance, there is only one sex through which

the quality of the egg-yolk can be influenced—the hen. With the bee there are two individuals—the queen and the nurses—that can both influence the quality of the egg-yolk. With the bee the maternal function is divided between the queen and the nurse—one part consists of ovipositing and the other nursing. Both parts consist of the production of substances from the individual, and both productions form conjointly the food that shall decide the quality of the future creature.

The reason for this double function in the bee is owing to the bee-egg not carrying sufficient food to take the larva to the time when it will emerge from its cell, a weak but completely developed individual. To the nourishment in the bee-egg more must be added. Some of this additional food is consumed by the larva prior to the sealing of the cell, and some is stored away in the fat body of the larva to be drawn upon according as development into the perfect insect progresses. This extra food is supplied by workers of an age when certain glands are active. Because of this function or nursing, these young workers have been appropriately termed “nurse” bees.

In addition to loss of stamina through insufficient or improper nourishment, loss can also oc-

cur through the too heavy egg-production of the mother. If a female has been so bred that her egg-forming organs work at a higher rate than those connected with the process of digestion and assimilation, it naturally follows that her eggs will be under-nourished, and therefore of little value for the maintenance of stamina in the offspring produced from her eggs.

It seems to be a settled principle in nature that the younger the creature, the richer shall be its food. The milk of a cow is well known to be at its richest at the commencement of the lactation period, and then gradually declines in quality as the calf grows older. A similar state is found with the common fowl's egg, containing no less than forty-five per cent of fat.

While, as previously stated, there is no stamina factor, there is a method that permits of fairly gauging the bees' possession of that quality. About three weeks before the expected honey flow, and preferably on the same day, run rapidly through the apiary and jot down the brood contents of each hive. Keep a record of the surplus from each hive, and at the end of the season compare the amount of brood each hive had on examination with the amount of surplus the corresponding stock gave during the season. If it is found that the two best stocks showed nine

and twelve frames of brood respectively, and each gave 100 lbs. of surplus, it will be known that, other things being equal, the stock that had the nine frames of brood possessed stamina in a higher degree than the other.

Longevity

This is another desirable quality in the bee about which little has been said. It is now and then mentioned in the bee journals, but with no attempt to explain its loss or acquisition.

Longevity is inseparably associated with stamina; where the latter is, there must necessarily be longevity, since the latter is only an expression of the former.

Disease Resistance

There is another quality associated with stamina. We make here no reference to the debatable subject of immunity. While there are stocks that do show high powers of resistance to disease, immunity is in quite a different category.

Docility

This is an important and most desirable characteristic, since it adds much to the pleasure of bee-keeping and much to the comfort of those

who have to work for lengthy periods in the apiary. There is scarcely anything more irritating than continuous threatening or actual assault by cross bees.

But the bees are not always to blame. Many bee-keepers have such peculiar methods of manipulation that they tend to develop bad tempered bees.

We believe there are two factors that contribute to the development of a bad disposition in the bee. First, excessive and undue manipulation. The hives are opened frequently when there is no actual necessity to do so. Especially is this the case with beginners when some success has been gained.

The inside of a hive is without doubt a wonderful land awaiting exploration, but it would be far better to do the exploring with as little disturbance to the bees as possible. That can be done through the use of an observatory hive. This need not be an item of great expense, for the average handyman could make one himself at little cost.

Secondly, we are of the opinion that the hive is frequently opened before the bees are fully under control. The instruction is to blow a puff or two of smoke in the entrance, wait a few moments, and then raise one corner of the quilt, and

again use the smoker over the frames. That may be sufficient where the bees are particularly docile, but in the case of bees having a warmer disposition, it is not so. The bee does not fill itself in a few moments with honey, and unless it is full, its natural instinct is to defend the stores that are still in the hive. The use of the smoker is to compel the bees to load themselves with food, but if the bees are not given a chance to do so before the hive is opened, control has not been obtained.

Non-Swarming

This is one of the most desirable characteristics the bee can possess. It tends to the production of a large surplus and at the same time reduces the labour incidental to the hiving of swarms.

Swarming divides the force at the very period that unity is most desirable; but although that division can be overcome, it is at a cost of time and labour. Where many swarms are dealt with, time and labour thus expended are serious items, especially where the bee-keeper has to attend to other matters.

Should the swarm decamp before the bee-keeper is able to hive it, there is a loss of both capital and income.

Non-swarming is altogether a most desirable

character and one the apiarist should do his utmost to develop. On this subject we shall have more to say in another place.

Early Breeding

This is another characteristic that is essential in the bee. But it should not be confused with rapid spring development. In our opinion a rapid increase in the production of progeny is a factor leading to the development of the swarming instinct. Early breeding will give better results, as by it there is no sudden addition to the population, and no necessity for the superfecund queen.

The principal stimulus to a colony after the winter semi-hibernation, is the presence of fresh pollen in the fields. This is usually available in quantity at the beginning of March. If the queens are possessed of the instinct of early breeding, there will be a gradual extension of the brood nest at that time. This is just what is required: an early, gradual, continuous, and progressive building up, in preference to a sudden expansion of the brood nest rather later in the spring.

With such queens the extent of the brood nest is never beyond the capacity of the bees to cover it, with the result that there is very little proba-

bility of chilled brood consequent upon a cold snap.

The aim in spring management should be the production of the maximum population of field bees at the commencement of the main honey flow. This occurs in the majority of localities about the middle of June. Assuming about six weeks for the development of a field bee from the egg, all the worker progeny from eggs laid in the months of March and April should take part in nectar gathering at the opening of the flow. And it is not asking too much from a robust queen carrying this characteristic of early breeding to produce a daily average for these two months of one thousand five hundred eggs. That would provide a field population of ninety thousand—a number that is never reached by more fecund queens that are without the instinct of early breeding.

Moderate Fecundity

After what has been said on the subject of stamina, the reader may not be altogether surprised to find the moderately fecund queen advocated in this work.

Progeny is produced at the expense of food and energy, both of which should be conserved, but especially the latter. This, the moderately

fecund queen does: there is no excessive breeding at any time, neither is there breeding out of season.

The question of prolificacy is one closely connected with that of stamina. A queen may be bred for superfecundity, but there is absolutely no proof that it is possible to increase proportionately the functional activity of the organs concerned in the processes of digestion and assimilation, and, in the case of the nurse bee, the secretion of larval food.

Because of the persistent advocacy of the superfecund queen, one would almost conclude that without her a profitable surplus was impossible. But such is not the case.

In this advocacy probably no writer has been so frequently quoted as Doolittle: "Give me a good queen," he wrote, "one which can be brought up to the highest production of eggs just when we want them, and I will show you a honey crop, if the flowers do not fail to secrete nectar; but with a poor queen—one that you must coax for eggs, to little or no purpose—the flowers often bloom in vain, even when the honey secretion is the greatest. . . ."

Would it surprise the reader to know that Mr. Doolittle himself had experience with one of those queens that he thought "poor" because she could

or would not conform to his standard of "goodness," which principally consisted of the number of eggs a queen could produce: and that the same queen outclassed his own? But let us give the account as related by himself in the pages of *Gleanings*: ". . . During the middle 90's, one of our most successful comb-honey producers desired to exchange queens . . . we did so. I gave this queen my best care and attention: but the best she would do at brood-rearing was to the amount of about six Langstroth frames full. I was disappointed, as many of my queens would give to the amount of eight and nine frames practically full of brood. So I marked the colony as one whose queen should be replaced with one more prolific. My time for superseding queens is when the flow of white honey is nearing its close: but when I came to this colony, I found that it had stored and completed more sections than had any of the colonies having queens giving eight and nine frames of brood. This led me to keep the queen for another season.

"The next season proved a repetition of the year before: and while her bees did not seem to start out to work any earlier in the morning or work later at night, nor seemed to be doing a 'rushing' business at any time, they kept steadily at it with the work in the sections slowly

getting ahead of those which made a greater showing as to working numbers at the entrance. This queen lived to be nearly five years old, her colony held the 'banner' as to completed sections for four years, and from close observation, longevity of the worker bees was the only reason I could ascribe to account for their superiority. . . ."

Mr. Doolittle could never have realised how damaging that account was to his own method of breeding. He had well over twenty years in which to prove his method of queen rearing before he received that queen, and although there is no evidence to show how the new queen was bred, it is more than probable that she was reared by a method different from that of Doolittle's. For four consecutive years that "poor" queen outclassed his own, and he himself assigned as the reason for her workers' superiority, their being possessed of longevity. Since longevity, as previously shown, is inseparably associated with stamina, the inference is obvious.

It can confidently be asserted that there is no other direction in which vital energy is so soon dissipated as excessive generation. In the case of the bee, stamina or vital energy is an absolute necessity, seeing that its life can be summed up in the one word "work." And by the natural di-

vision of the castes of the bee into two classes—one that produces offspring, and the other made sexless that generation may not interfere with its labours of providing that offspring with food—nature indicates in no uncertain voice that procreation and work, both of which require the expenditure of much energy, are incompatible.

CHAPTER IV

RAISING QUEENS FROM EGGS OR LARVAE

Laws

In artificial breeding-operations it is most essential that the methods employed should be in accordance with natural laws.

The use of any methods outside those laws must, as being against the principles that evolved the creature to the stage where we find it, have an influence adverse to its further evolution. Live-stock breeding is or should be, the application of those principles in such a manner as to exclude the interference of other forces that may tend to retard or avert a desired result. And as all nature is guided by certain principles, it devolves upon us to discover those that have connection with our breeding operations, and work in conjunction with them.

We sometimes find that as our knowledge increases, the theories on which we had previously based our breeding were in some particulars

against natural laws; that they were incapable of explaining certain phenomena; or that they carried contradictions among themselves. Until such discoveries are made, we are apt to be satisfied with the original theories and seek no further. Up till then that attitude is quite correct; for a complete system of theory and practice is usually logically sound, and appears to be unassailable, until we get new and strange results from our practice. Since we cannot put aside our experiences, we are necessarily compelled to re-examine and revise or discard our theories according to the new results.

Furthermore, in all breeding operations, it is imperative that the breeder fully understands the nature and peculiarities of his stock, and, while adhering closely to nature, employs the general principles of breeding in such a manner as shall increase the economic value of the stock, and yet conform to its needs and nature. Most particularly does this apply to the bee-breeder. His bees, in comparison with other domestic stock, are quite exceptional, having the following characteristics possessed by no other:—

Characteristics Peculiar to the Honey-Bee

- 1.—The bee is able to raise male or female progeny at will.

- 2.—The bee is subject, in one caste, to parthenogenesis.
- 3.—The testes of the drone secrete sperm for a short time only and then degenerate.
- 4.—The male performs the procreative act once only in his life, which ends with that act.
- 5.—Functions of maternity are divided between the true female—the queen—and her unsexed daughters—the workers.

The vital thing in live-stock husbandry is the breeding, since it is through that alone that the economic value of a stock is increased. It is, therefore, most essential that the theories of bee-breeding be in complete agreement with observed facts. At the present time such is not the case. Breeding experiments show those theories to be either incomplete or inaccurate, which is not surprising seeing that the latter originated three quarters of a century ago.

Food Theories and Their Relation to the Castes

The greatest problem in bee-breeding is undoubtedly the means by which the bee is able to raise either queen or worker from the same kind of egg. That knowledge is fundamental to the use of correct methods of breeding, for if such knowledge is not employed it is obvious that progeny

will not be reared likely to be of the greatest profit to the owner.

Many theories have been formulated to account for the peculiar ability of the bees to control the ultimate caste of the larvae. And those theories have been in nature as wide apart as the poles of the earth.

An extensive investigation into breeding conditions, however, fails to disclose any causative influence, other than that of food to account for the bees varying the caste of the larvae at will. And we believe that no matter what other theories are or have been held, the open-minded investigator will ultimately be compelled to return to the food theory.

The food theory, together with the discovery that the bees could raise queens from worker-larvae up to three days of age, was the original theory on which breeding is based. But, as we previously indicated, breeding practice has shown those theories to be insufficient. And it is worthy of remark that it was principally an unconscious recognition of that insufficiency, that was the cause of so many theories being advanced to account for the raising of a queen or worker from the same kind of egg.

All larval food is said to be identical in composition and to be fed to all larvae up to the age

of three days. If a larva is to develop into a queen it continues to receive this food throughout the whole of its life; if the larva is to develop into a worker, its food is said to be reduced in quality after the first three days. This change of food is said to prevent the development of the larva's sexual system and therefore the larva that would have normally developed into a queen, is converted into a neuter. These were the original theories, but they have been somewhat altered as we shall show in the course of the discussion.

The foregoing theories, which are principally due to Leuckart, we shall in future term the "identity" theory in so far as they apply to larval food.

With Leuckart's theories was associated the discovery of Schirack's that the bees were able to rear queens from worker-larvae up to three days of age. It will be noticed that these theories mutually support each other, and it was their combination that eventually constituted the original basis of queen-rearing.

A close study of those theories brings to light a rather curious omission; in not a single case was anything advanced to explain the development of the drone. In this matter we are up against a serious problem. We know that the drone's testes are very similar to the ovaries of the queen;

in fact, they are homologous. Yet, although his treatment in the larval stage is said to be similar in every respect to that of the worker, it is most strange that the change of food that operates to prevent the development of the genital organs of the worker-larvae should not operate in the case of the drone-larvae. And not only is the development of those organs not prevented, but they are actually accelerated, for the drone's testes are fully developed to an enormous size much before the corresponding organs of the queen, and when the drone is in the pupal stage.

A further investigation into orthodox theories relating to the breeding of the bee, shows them to be incapable of explaining why the bees ever use eggs instead of larvae from which to raise queens. In such a matter as breeding, we think it a reasonable assumption that the bees know more about the matter than we do, and therefore the fact that eggs are used for that purpose by the bees should be sufficient to cause a closer examination of the subject than has hitherto been accorded to it. There must be a reason for the bees' use of eggs, and it becomes our duty, privilege and pleasure to endeavour to find that reason.

Still further, modern theories do not explain why queens raised from larvae become smaller in proportion to the age of the larvae from which

they are reared; in other words, the older the larvae, the smaller the queens. No reason whatever has been assigned for this peculiar result. We think it peculiar, because all larvae are said to receive similar food up to three days of age, but were there any truth in the theory, there should be absolutely no difference in the size and quality of queens raised from larvae of an age anywhere within that period. But there is a difference, not only in size, but also in quality, and we feel compelled to accept that difference as another proof of the inadequacy of present theories. Because we cannot put aside the result of our experience, we are compelled to re-examine those theories and amend, revise, or discard them as the case demands.

Beyond, however, the failure of orthodox theories to account for various important phases of breeding, the "identity" food theory implies far too much. It implies that the so-called worker-egg is really a queen-egg, and that its normal development would be into a queen and not into a worker. Seeing, however, that an ordinary queen is capable of producing roughly two hundred thousand eggs per annum, and would produce at swarming time only about a dozen queens, it seems a strange proceeding that nature should compel the bees to operate in some way

in every one of those two hundred thousand individual workers, against its normal and natural development, while in only a dozen swarm-raised queens there should be a normal production.

In a previous chapter we pointed out the division of the maternal function between the queen and her neuter daughters. For this division of labour there are several weighty reasons connected with the life, generation, and purpose of the honey-bee.

In the first place, it would be impossible for a single creature to produce the huge number of eggs as does the queen-bee, and at the same time nurse the resulting progeny from a glandular secretion as is required by bee-larvae. The egg-laying part of the maternal function is sufficient for the organism of the queen. Secondly, the large amount of food required for the growing larvae is such that no single individual as the bee could provide it. Why nature did not arrange that the bee-egg carried sufficient nourishment to complete individual development, as in the case of the fowl, is a problem that we shall endeavour to solve.

The bee is an aid to nature in fertilising flowers; but it must have some inducement to visit the flowers. That inducement is found in the

nectar that provides one portion of the bee's food. That nectar has to be gathered, and nature provides a caste of the bee—the worker—that is physically adapted to that work. This caste—the worker—forms the backbone of the colony; it must always be present, for without it there would be no such thing as a stock of bees. A colony of bees whose members consisted of an equal number of queens and drones, would be singular; and although they are the two reproductive castes, they could not, either combined or separately, form a colony that would survive the consumption of its own stores of food.

The Relative Position of the Castes

Without making unprofitable speculations on the relative position and evolution of the castes of the bee in the dim past, and taking the bees as we now find them, it appears that, since the neuter controls the production of the three castes and must always be present, it must be accepted as being the normal caste; and since the queen and drones are raised by the workers for a definite purpose, and in comparatively small numbers, they must be looked upon as being the exceptional. From which we logically conclude that the bees employ exceptional means by which to raise those exceptional castes.

It will be perceived that the ability to raise any caste at will is a necessity in the case of the bee. There must be no superfluous males to consume the winter supply of food so laboriously gathered by the workers, and since the workers themselves perform one part of the maternal function, there is no necessity for more than one fertile female in the stock.

The ability of the worker to control the future caste of all larvae makes it the dominant caste of the colony; and as it has the responsibility of the whole family on its shoulders, even to providing it with both parents and food, it is reasonable to assume that it must have the power and means necessary to perform its duties and execute its trust. The worker has both power and means, and they lie solely in its possession of the ability to control, through the food supply, the future caste of the larvae. Here we have the first reason why the bee-egg is not supplied with sufficient nourishment to take the individual larva to maturity. Had the bee-egg that nourishment, it would immediately eliminate the worker as the nurse: the egg without that nourishment at once elevates the caste that can supply the deficiency, to the ruling position in the stock.

The nature of the bee; the conditions under which it exists; the object of its life, all make a

division of the maternal function imperative. And the possession of control over the larval-food supply, since on it is based the continuation of the colony, is the key to all problems connected with the actual breeding of the bee and the ruling of the stock.

Some Difficulties of Present-Day Food Theories

Some observant apiarists, among them being the late Mr. Cowan, while adhering to the "identity" food theory, could not satisfactorily account for the superior quality of those queens that had been raised from the egg, over those that had been raised from larvae, and suggested that it was the abundance of food at the commencement of the queen-larva's life that was the cause of that difference. They, therefore, advised rearing queens from eggs instead of from larvae, so that the larvae might be certain of that abundant feeding at the time of hatching.

While every bit of evidence is against the "abundance" theory, as will be shown, it certainly leads us to the key of the problem. The amount of food a worker-larva receives on the first day of its life is about four times the weight of itself; an equivalent amount of food supplied to a newly-born human baby would be about a quarter of a hundredweight! And at no time is the larva

without more than sufficient food than it actually needs. Therefore, the addition of an extra quantity of food could have no influence, *unless the extra food was different in quality*, which suggestion brings us to the only possible solution, namely: that there are two kinds of larval food used by the bees in controlling the castes of the larvae. This theory we shall now term the "two-food" theory.

From the "identity" theory arises another: that the change of food prevents the natural development of the larvae. On the other hand the "two-food" theory assumes that the food used to produce a queen is used both to change and accelerate the development of the queen-larvae. The queen develops in sixteen days: the worker in twenty-one and seeing that the queen is a more highly organised individual than the worker, and matures in much less time, the acceleration theory is more reasonable and in accordance with facts as we know them, than the prevention theory which, with its correlative theory of food identity, is insufficient to explain several points peculiar to the breeding of the bee. On the other hand the "two-food" theory and its correlative theory of acceleration, is sufficient to cover all the ground, and is, further, in agreement with other experiments carried out with other animals.

Previously we referred to the use of eggs by the bees in rearing queens. There are two conditions under which the bees naturally do so, viz., *supersedure*, when the old queen begins to fail; and that of *swarming*, where a portion of the old stock with the old queen leaves the old home to seek another elsewhere. Another condition under which bees will raise a queen is that of *queenlessness* which, being the result of accident or the interference of the apiarist, is unnatural and therefore in a category different from that of the others. In the former cases the queens are deliberately raised from eggs which, *before they hatch*, are destined by the bees to produce queens. In the last case of queenlessness, through the sudden and unexpected loss of their queen, the bees are caught unprepared and make haste to rear another queen. In doing so they use larvae instead of eggs.

The orthodox method of queen-raising is opposed to the natural way of raising queens, since by it larvae are used that are transferred from their original cells into others specially prepared for their reception and accommodation, until the larvae emerge therefrom as queens. Therefore, there is no difference between queens so bred and those raised by the queenless impulse, except that some breeders, knowing from practical ex-

perience that the better queens come from the youngest larvae, use the latter as young as is suitable for transferring, in preference to those of greater age and size. But since there is a certain amount of prejudice against the theory here propounded, we append the following extract from Roots *A.B.C. and X.Y.Z. of Bee Culture*, page 688: “. . . The old way of raising queens was to make a colony queenless; wait for the bees to build their own cells; then distribute them to colonies made queenless beforehand. This plan was very slow and wasteful, and *worst of all results in the rearing of inferior queens.*” (Italics ours.)

To those who have thoroughly tested the value of the egg-raised queen, the superiority over her larva-raised sister is an established fact—a fact that no paper authority can disprove. It is a fact from which there is no escape; to deny it, those who knew the truth would have to deny their own reason and their own experience.

It appears to us that the operative food factor that changes the caste of a larva is that of quality only, and we shall produce evidence to support that assumption that will satisfy all but the most biased. In natural rearing the bees use eggs, and for that they must have some weighty reason. That reason we believe to be the neces-

sity of providing a queen-larva from the very commencement of its life, with its own particular food, which has, and is used for, its own particular purpose. Here we have the second and weightier reason why the bee-egg does not contain sufficient nourishment to take the larva to maturity. The bee-egg without that nourishment permits the nurse bee to add, *at the time of hatching of the egg*, the deficient food in the *quality* required by the individual larva according to whether it is to develop into a queen or worker. Had the bee-egg the necessary nourishment in the first instance, the two castes—queen and worker—would be raised simultaneously in about equal proportions when breeding was taking place, with the result that there would be no dominant caste in the colony, an insufficient amount of food in the working season owing to the reduced number of gatherers and the increased number of consumers, and no reserve food for the winter. Such a condition would be chaotic and quickly result in the extinction of the bee. A larva-raised queen, on the other hand, does not receive the royal jelly until it is given it by man in the case of artificial rearing, or by the bees in the case of queenlessness. This explains the difference between queens previously noticed—a difference that is caused by withhold-

ing from the larvae between the time of hatching of the eggs and the commencement of the converting process, the only agent that is capable of producing a full queen—royal jelly; and the period between those two events results, according to its length, in the production of good or bad queens, *i.e.*, the shorter the period, the better the queens. Later we shall offer some evidence of a scientific nature that is not short of decisive.

The advocacy of the egg-raised queen naturally implies opposition to that raised from larva, and, strange as it may seem, he who originated the present method of raising queens from larvae had also testified to the superiority of the egg-raised queen! We refer to Mr. Doolittle. In his work on *Queen-Rearing* he wrote, page 14, "... This swarming trait also produces queens of the highest type of perfection, not being equalled by any, except those reared under one other of nature's conditions, which will be spoken of at length in the next chapter. . . ." The other condition referred to was that of supersedure. In the same work, page 28, he has also similarly testified: "... By now supplying them (queenless bees) with from twelve to fifteen larvae, all cradled in queen-cells, upon which they may bestow all the provision and caresses that they were

bestowing before on a whole colony, it could hardly result otherwise than in *producing as good queens as could be produced by any plan not exactly in accord with nature's ways. . . .*" (Italics ours.)

Here we have an admission that Doolittle knew of the superiority of naturally-bred queens, *i.e.*, those raised from the egg, and it is simply astonishing that he should have allowed a food theory to over-ride his experience in this matter.

However, we shall show that he also knew naturally raised queens to be bred from the egg, which he afterwards denied, although that denial may have been made inadvertently.

On page 17 of *Scientific Queen Rearing* Mr. Doolittle wrote: ". . . When this condition of things (preparations for swarming) prevails, the bees are getting strong in numbers and soon embryo queen-cells are started in which the queen lays the eggs, which are to produce the royal occupants. Some claim that it is not fully settled that the queen deposits the egg in the queen-cell at the time of natural swarming; but my assistant once saw her do it, and so have others, while the position of the eggs in the cells proves it. . . ." Mr. Doolittle also thought that the same conditions of rearing queens from eggs applied to those queens reared under the superse-

dure impulse, for we find him on page 19 of his work to the following effect: “. . . Right here let me say that from all of my experience with bees, I am led to conclude that 999 queens out of every 1,000 reared, where man does not interfere with the bees, are reared by one of these two plans. . . .” Those two plans are swarming and supersedure.

It may be thought that these were the earliest opinions of Mr. Doolittle, but that supposition can be shown to be baseless. It was in the early seventies of the last century that Doolittle commenced rearing queens from larvae, and he wrote his book in 1888, and nowhere mentions a change of opinion. He advances the above as an integral part of his theories, and we cannot help concluding that Doolittle became so enthusiastic over his discoveries, that he permitted himself to be blinded to the true position in the matter of breeding.

We have now to quote a passage that, up to the present, has not been questioned; yet it contains statements that can be proved to be either erroneous in themselves, or based on theories that can be shown to be erroneous. In the book referred to Doolittle wrote, “. . . I also claim that the food fed to all larvae up to the time they are thirty-six hours old, is exactly the same,

whether the larvae are destined for drones, queens, or workers; and that the difference comes by the queen-larvae being fed in large quantities of this food all its larval life, while others are fed sparingly later on, or else a different kind of food given after they are thirty-six hours old. Some experiments which I have conducted point in this direction, but as yet I have not completed them fully enough to warrant the giving of them here. If the above is correct . . . it will be seen that the larva in a worker-cell has all its wants supplied for the first day and a half and is developing towards a queen just as fast, prior to this, in a worker-cell, as it possibly could in a queen-cell, surrounded by ten times the food that it can consume. Hundreds of experiments in using larvae from three hours old, up to those of thirty-six hours, prove that queens from the former are in no way superior to those from the latter, while the bees always choose the latter when the power of choice is left to them. . . .”

It is strange that throughout all these years the assertion contained in the last sentence of the above extract that bees, having the power of choice, always select thirty-six hours' old larvae from which to raise their queens, has never been questioned, nor even commented upon. Yet there is hardly a single apiarist with a couple of

seasons' experience, who does not know it to be false. Its falsity is shown by the previous extracts from Doolittle's same book dealing with the raising from the egg of swarm and supersedure-bred queens, and it is against every experience that has been recorded.

It would be interesting to know on what grounds Doolittle made the claim about larval food, for his claim, if correct, either invalidates the findings of Leuckart to the effect that the change of food was made at exactly the same time as the female genital organs began to appear, *i.e.*, at the end of the third day, or, by the introduction of a second theory, tends to support the author's contention regarding larval-food and its operation in converting a worker-larva into a queen. We shall show elsewhere that Doolittle's food theory does the latter and not the former.

We would now draw the reader's attention to that part of Doolittle's claim where he gives an alternate theory to that of *quantity* of food fed to the larvae: it is that the changing of the caste may arise from the feeding of a *different kind* of food; in other words, food of a different quality. Incidentally, when Doolittle attributed either quantity or quality of food as being the cause of larva-conversion, he was certain of being right,

since there are those two possibilities only. But the fact that Doolittle had the two theories in mind, shows that he had entertained the same theory that is propounded by the author, namely, that there are two kinds of food fed to larvae—one kind to the worker-larvae and another to the queen-larvae.

Had Doolittle followed up his “quality” theory, he might have received some explanation as to the death of his larva-raised queens, and the flourishing of his swarm-raised queens.

Evolution of Theories

Glancing back over the years from the present to the time of the birth of the “identity” food theory, that, together with the discovery that queens could be reared from larvae up to the age of three days, has constituted the basis of modern breeding methods, we are struck by one outstanding fact—a fact that few, if any, have observed, but one that has considerable bearing on the subject of breeding.

All down the years from the formulation of that theory, a gradual alteration in breeding methods is found to have taken place. At first, it was considered sufficient and as being in accordance with nature, that when queens were to be raised it was only necessary to remove the

old queen and allow the bees to raise others according to their own sweet will. That method was employed by the then most enlightened apiarists for some considerable time, and to a considerable extent, and unfortunately is still employed by some. Eventually experience proved that method to be unsatisfactory, and it was finally and severely condemned by Root in his A.B.C., from which an extract bearing on the matter has already been given.

As the years passed by and the demand for queens gradually increased, apiarists began to experiment in producing queens in large numbers. Among these we have Alley, who raised queens by the thousand. With him, however, the act of transferring larvae was not known, and he therefore used worker-cells cut down in a certain manner and containing eggs or just hatching larvae.

Then, conspicuous in the devolution of breeding, came Doolittle with another theory of larval food, reducing the time of receipt of similar food by all larvae from three days to thirty-six hours. Doolittle's food theory, however, had no influence in altering the original theory because, we believe, the possibilities disclosed by raising queens from larvae had obscured the other and far more important subject of the means by

which the bees achieved the alteration of the caste of a larva. The larva-raised queen still held the field; but where the three-day-old larva had previously been considered quite as suitable as any other larva of less age for queen-raising, Doolittle reduced that period to thirty-six hours—a considerable jump towards the egg-raised queen.

As time went on and the results of experience became more manifest, others came forward and boldly proclaimed the superiority of the egg-raised queen. Among those was no less a person than the late Mr. Cowan. But the results of their experience were told to deaf ears.

During all this time the identity food theory had scarcely ever been questioned, but there arose a necessity to account for the difference that had been observed in practice between the queens raised from eggs and those raised from larvae. The failure to question the original food theory and the necessity to supplement it, resulted in the formulation of another theory—that of “abundance”—which theory has been previously discussed.

It will be observed that in the devolution of breeding there have always been some persons considerably in advance of others. Doolittle was an advance on Langstroth, and Cowan was an

advance on Doolittle. And it is a matter of some significance that this advance towards the egg-raised queen has been actuated by experience alone, and actually in opposition to accepted theories. Therefore, it is of more value than all the theories combined, and we submit that the alteration in breeding methods proves either the inadequacy or inaccuracy of orthodox breeding theories. Even now we have breeders of note who, although they use no other method of rearing but by transferring larvae, assert the superiority of queens raised from the youngest larvae. We consider that more than sufficient evidence to disprove Doolittle's contention that there was no difference between a queen raised from a three-hour-old larva and another raised from a thirty-six-hour-old larva.

It has been said that all these questions about breeding were settled half a century ago. That statement implies that finality in breeding had then been reached, but we venture to think that the discerning reader will conclude otherwise. The statement in itself may be true, but the implication is both misleading and false. Who tested the matter fifty years ago and where are we to find the records and results of the tests? We do not hesitate to say that no complete test has ever been made, and for that reason the

egg-raised queen is still an entirely unknown quantity—except to the very few. The statement is also misleading in that it is apt to lead the superficial thinker to believe that the conclusion reached was in accordance with established and unalterable facts. But nothing could be further from the truth; and as for the accuracy of the theories held at that time, a little investigation into the matter will be interesting and possibly instructive; at least we shall be able to ascertain how much “scientific caution” was employed in the making of the statement.

Any investigation into the theories of bee-breeding takes us back to the time of their formulation—three quarters of a century. It was in 1855 that Leuckart first propounded his theory of larval food, that up to only a few years ago was universally accepted, and is still so accepted by those who are unacquainted with the more modern investigations of the subject.

Leuckart is said to have discovered that worker-larvae, when three days old, have their food changed from the so-called royal jelly to another of an inferior quality; but that the queen-larvae continue to receive the same food the whole of their life. He also found the time of the change of food to coincide with the appearance of the female genital organs. In the

case of the worker-larva the change of food was thought to prevent the development of the sexual system, and in that of the queen-larva the continued receipt of the same food was thought to develop the ovaries.

Leuckart was confirmed later by Dr. Planta, who was the only one to have made a complete analysis of larval food. He concluded, however, that larval food was chyle. That conclusion, it should be carefully noted, was based on the great variation in the quality of larval food, which variation Planta thought was not premeditated by the bees. But the late Mr. Cowan thought that Planta's work conclusively proved that the variations are attributable to the nurse bees, which have the power of altering the food constituents to suit the requirements of the different castes. We certainly agree here with Mr. Cowan, since all the facts are too strong against any other conclusion.

We now come to a demonstration said to have been made by Schonfeld that larval food is produced from the chyle stomach of the bee, from which it is regurgitated for the purpose of feeding the larvae. In this matter he was supported by Dr. A. Planta, who also found that the food of the queen larva was unchanged, thereby confirming Leuckart. But it is difficult to see how

Planta could have arrived at the same conclusion as Leuckart without having been influenced by the latter's theories, since his own analysis actually disproves his own conclusions.

The disagreement between Planta's analysis and Leuckart's theory is so great as to necessitate an examination of the former. Therefore we reproduce Planta's table of analysis from Cowan's *Honey Bee* showing the percentage of the solid constituents of larval food.

Dr. Planta's Food Analysis

According to Planta, it will be seen that worker-larvae for the first food-period of under four days receive a food containing 53.38% of albumen. Were there any truth in Leuckart's theory, or were Planta himself correct, that queen-larvae receive the same food throughout their existence, the queen-larvae should receive food with the same percentage of albumen, viz: 53.38%, the whole of their life. But, on reference to the table, we find that the average amount of albumen for the whole life of the queen-larvae is 45.14% instead of 53.38%—a difference of no less than 8.24% in albumen contents, as compared with the first food-period of the worker-larva. Therefore, if the queen-larva receives food similar in quality to that of the worker-

larva for the first three days of its life, it follows from the table itself that the food of the queen-larva, like that of the worker-larva, must also be reduced in quality after the first three days.

We find, again, on turning to the column in the table dealing with the fat contents of brood food, a still greater divergence from what would naturally be expected, assuming, of course, the accuracy of Leuckart's theories. For the queen-larva it is shown that its food contains 13.55% of fatty substances, which quality of food it receives the whole of its life. Against that the food of the worker-larva for the first three days contains 8.38% of fatty substance, which quantity is afterwards reduced to the very small amount of 3.69%, bringing the average amount of fat for the worker-larva to 6.03%—less than half that received by the queen-larva. If again, the queen-larva received, for the first three days of its life, food having the same fatty contents as that of the worker-larva, it is obvious that the fat contents must be enormously increased after the first three days. The figures of the increase when worked out show it to be from 8.38% to the large amount of 18.72%. Instead, therefore, of Planta's analysis confirming Leuckart's theory, which was supported by Planta himself, it does the very opposite by disproving that theory.

TABLE FROM COWAN'S "HONEY BEE" GIVING
PERCENTAGE OF SOLID CONSTITUENTS
OF LARVAE FOOD AT VARIOUS PERIODS

Queen		<i>Albumen</i>	<i>Fatty Substances</i>	<i>Sugar</i>
		45.14	13.55	20.39
Drone	Under four days	55.91	11.90	9.57
	Over four days	31.67	4.74	38.49
	Average	43.79	8.32	24.03
Worker	Under four days	53.38	8.38	18.09
	Over four days	27.87	3.69	44.93
	Average	40.62	6.03	31.51

We are now in a better position accurately to judge the value of the conclusions that are supposed to have finally settled all breeding questions fifty years ago. And in forming that judgment we shall be greatly assisted by later discoveries, all of which, however, cannot be given here.

Dr. Koehler's Investigation of Larval Food

In 1922 Dr. A. Koehler made a new investigation of the question of larval food. She showed that brood-food is acid, while the contents of

the bee's stomach are neutral or weakly alkaline, thereby confirming the plentiful other evidence against Schonfeld's theory that brood-food is regurgitated from the stomach of the bee. It was further shown that brood-food agreed in chemical composition with the secretion of the pharyngeal glands, and that the composition of larval food is the same for worker and drone larvae, and does not change as the larvae grow older (except that pollen is mixed with it by the nurse bees in the case of the older larvae).

The Theories of Planta, Leuckart and Schonfeld Disproved

Dr. Koehler's investigation disproves both Leuckart's theory and Planta's food analysis, which, it may be remarked in passing, has now been entirely superseded. It also disproves Schonfeld's theory that larval food is chyle, and his other theory that the brood-food was regurgitated from the stomach. With the disproof of these theories, he who would rely on what was accepted fifty years ago is left entirely without support of any kind, since all the theories of those days are now known to be inaccurate. From this the reader will be able to form his own opinion of the value to be placed on the statement we have discussed.

Quality of Differently Bred Queens

We would now draw attention to the frequently reiterated dictum that larva-raised queens are the biggest and best. As regards their quality we know that assertion to have no foundation in fact, and as regards size we shall produce evidence of a scientific nature that totally disproves such a conclusion. We further believe that not a single apiarist making that statement has any acquaintance with the egg-raised queen extensive enough to justify such a claim.

Elsewhere we showed that longevity was simply the expression of stamina and that without the latter there could be none of the former. We can, therefore, get an adequate idea of the quality of a queen by recording the length of her life. Among the ample evidence bearing on this subject, there is tucked away in an obscure corner of Root's A.B.C. a statement that some queens die, seemingly of old age, in the second season. That statement can have reference to the larva-raised queen only, since her egg-raised sister is an entirely unknown quality and could not, therefore, be included. And we believe, furthermore, that such deaths are of more frequent occurrence than is generally supposed. We could produce evidence, did space permit, to

prove that a very large number of larva-raised queens are superseded early in life and quite unknown to the owner. On the other hand, we have never come across or even heard of egg-raised queens that suffered such an early extinction. On this subject we can, however, offer one piece of evidence: the experience of one who is a keen observer of things apicultural and a regular contributor to *Gleanings*: Mr. J. R. Byers, who wrote in that Journal, “. . . Speaking of queen bees may I be allowed to forecast that in the near future there will be some radical changes made in the methods of raising them? Lately we have heard much about raising from egg instead of transferring larvae, and I believe this is one step towards the change that is apt to take place. Anyway, I am firmly convinced, after an exhaustive test, that queens reared by transferring the larvae do not live nearly so long as those reared under the swarming impulse (from eggs). I base my belief on a large number of cases taken collectively, and not on individual cases which prove nothing one way or the other. . . .”

Dr. Becker's Experiment

On the question of the size of larva-raised queens in comparison with those raised from

eggs, we cannot do better than mention the results of an experiment carried out by Dr. Becker.

It is well known that the weight of a queen is considerably above that of a worker, and Dr. Becker's experiment consisted in weighing queens from larvae of various ages with the following results:

Queens raised from 1 day old larvae	100%
" " " 2 " " "	99.08%
" " " 2½ " " "	92.54%
" " " 3 " " " and upwards	81.77%

Those results disclose the fact that the further the worker-larva is from the egg when its development into a queen commences, the nearer the resulting queen approaches the worker in weight. All the larvae used in that experiment had, according to orthodox theories, received royal jelly all their lives, and on those theories their varying weights will take some explaining.

Here is, we consider, a confirmation from a scientific source of the author's contention that the difference in the quality of queens raised from larvae of varying ages, is due to the absence from the time of hatching to the commencement of the converting process, of the only known agent that is capable of that conversion—royal jelly, and that the experiment becomes another

finger post pointing to there being two kinds of larval food, or at least, to the possibility of the bees being able to alter the larval food at will.

Why a queen from a day-old larva was selected as producing a 100% queen, considering that in natural rearing the bees use eggs for that purpose, appears to be inexplicable, but there is a reason little suspected by the ordinary apiarist, and one that is quite foreign to the question of right or wrong methods of rearing.

Previously, we mentioned how the failure to question the orthodox food theory, when found to be insufficient for practice, had resulted in the formulation of another—the theory of abundance. When the insufficiency of this last theory is pointed out, it is advanced that the worker-larvae are restricted in the quantity of food, so that they have to wait for the nurses to provide it. This latter proposition can be disproved in any apiary in five minutes, but it is necessary to record it, if only to show how theory is piled on theory, when any one theory is found insufficient to explain facts, until the original theory is almost lost to sight, and the subject becomes so complicated as to be almost incapable of being understood. The original food theory was one of quality and had nothing to do with any

theory embracing the question of quantity of food.

The difference, however, between the organism and function of a queen-bee and those of the worker, is so vast as to render us quite incapable of accepting the cause of that difference as being due to a minute extra quantity of food. An alteration in the quantity of food supplied to a creature may result in an increase or decrease of its well-being, or may influence the production of a commodity from itself, such as eggs from the fowl, and milk from the cow; but the proposition that an extra quantity of food is sufficient to account for the stupendous change in a queen from a worker is too fanciful for serious consideration.

The Effects of Environment

Experiments on the effects of environment on lower animals prove that most marvellous variations in their growth may be effected by interference with the chemical conditions of their food and surroundings. Food entering an organism maintains the relative constancy of that organism; but by substituting one ingredient for another or by depriving the food or environment of one or more ingredients, the state of an animal may be varied in many ways, even to the

conversion of a creature into another species. Thus we are told of an experiment on the Brine shrimp, one species of which was manufactured into another species by gradually altering the salinity of the water. We are further told that the eggs of the sea-urchin, whose normal environment is sea-water, will fail to develop if the sodium is removed, but will do so if the sodium is replaced; but that if the sodium is replaced by lithium the eggs develop into monstrosities.

There is also the frequently quoted experiment on tadpoles advanced to show how good nutrition favours the production of the female sex. That extra nutrition does so act is most likely, but the experiment is often quoted as showing the results to be consequent upon the tadpoles having received additional food only. That, however, was not the case. Yung had to increase the food in *both* quantity and quality before he was able to increase the normal percentage of females.

Some Breeding Difficulties

The suggestion that the food of the worker-larva is reduced in quantity gives rise to another difficulty. The life function of the worker is labour. For such the worker requires the most

robust constitution, and we fail to see how nature can provide that constitution by stinting the food of the bee, when, we might say, it is in the baby stage. Almost everyone is aware of the disaster following a scarcity of food when the creature is young, and there is no valid reason for thinking the bee to be different in that respect from other stock. And the suggestion further implies that nature knows no other means to prevent the larva's natural development into a queen than by reducing the quality and quantity of its food, thereby making inevitable a reduction of its vitality. Such a proposition we cannot accept.

There is still another difficulty to be overcome. The food fed to larvae irrespective of their ultimate caste, is not all consumed by the larvae at the time of its receipt, but some is stored away in their fat bodies for use in development after the sealing of the cell. That food must have an influence on development according to its quality only, since the larvae have capacity for a certain and limited quantity of food and no more. This we believe to be the real cause of the variation in the weight of the queens used in Dr. Becker's experiment. The quality of larval food must have an influence as stated, and if worker-quality food is supplied for a certain initial

period, the quality and the weight of the queen must be reduced. And further, the provision of an inferior food must result in some loss of stamina, and, therefore, this theory of post-sealing development is in full agreement with the facts about egg-quality discussed in the chapter dealing with stamina. One supports the other in a surprising manner.

There is still a further difficulty to which the "Identity" food theory can give no satisfactory solution. We refer to the problem of the laying worker. In this matter there are absolutely no grounds for inferring that such curiosities have their ovaries stimulated to function by the consumption of an extra supply of larval food. On the other hand, it is a reasonable assumption that such function was and is developed by another kind of food. Huber thought that the ovaries of the laying worker were developed by the accidental receipt of royal jelly by some larvae near queen-cells, thus showing that he held that royal jelly differed from larval food as received by the worker-larvae.

Quality Versus Form

To one making a superficial study of the various results in breeding experiments, it would appear that both scientist and layman use the

same terms in relation to the same things, and with similar meanings. This, we believe, is not the case. Where the layman breeder always looks for "quality" in queens as disclosed by their worker progeny, we believe the experimenting scientist to be more concerned with the "form" of the queen at emergence. We do not suggest that that is the only direction in which the scientist looks for qualities. We apply it only to the case where it is said that the best results in rearing are obtained from using larvae of a certain age. It is an important point that the reader should bear in mind, for the reason given for preferring larvae of a certain age is given in a manner that is likely to obscure the true position. The real reason is that from those larvae there are less rejections by the bees than from younger larvae. The reader will see that this has nothing to do with the *quality* of the queens, but the statement that best results are obtained from larvae of a certain age, is one that would most likely lead the unobservant inquirer to conclude that it did. It is purely a question of what method gives the experimenter greater success in producing the larger number of queens from a given number of larvae.

There is not the slightest doubt that a *perfect* queen, as regards *form*, can be and is obtained

from a larva up to three days of age. But we think it misleading to use the word "perfect" unless it embraces quality also. A creature may be perfect in form, but fail in function through a lack of vitality, thus affecting the making of profit, or resistance against disease. We get a good illustration of what is here advanced, in the case of Doolittle's larva-raised queens that died. He himself referred to those queens as "my beautiful queens," which shows that as regards form and appearance they were quite satisfactory; but their appearance did not prevent their deaths, the reason for which Doolittle himself assigned to their inferior quality.

If there is any one theory in bee-breeding in which absolutely no error can be made in its application, it is that the better queens are those raised from eggs. It is nature's way and the bees' way, and as they know more about the matter than we do, we can very well trust them and nature to provide the correct food in the quality and quantity necessary for the purpose in hand. Here there is no guess-work, but a clear cut path to correct practice.

But with us the superiority of the egg-raised queen is no theory—it is the one outstanding fact—and whatever new facts may be eventually discovered or new theories formulated, that

fact will always remain. What is necessary and what has been the endeavour in this work is to put both theory and practice on such a basis that when practice is contrasted with theory, the latter shall not be found insufficient.

The Final Appeal to Experience

In everything pertaining to life, the final appeal must be to experience. No theories can overthrow that, but to it all theories must bow. Therefore, we append the conclusions of two authorities, whose qualifications and experiences are such as to put their considered judgment beyond all doubt.

Mr. Jay Smith, one of America's foremost breeders, expresses his conviction with no uncertain voice, that the best queens come from young larvae—"the younger, the better," he says. Since the youngest larvae are those just hatched from the egg, Mr. Smith is considered to have fully supported the author's own conclusion on the subject.

Another to give unqualified support to the method of breeding advocated in the foregoing pages, was the late Mr. Cowan, the father of British Beekeeping, from whose work, *The Honey Bee*, the following is extracted: ". . . In artificial queen-rearing, we have always insisted

on having queens started from the egg . . . as experience has taught us that such queens are much more prolific and vigorous. . . .”

Undoubtedly the teaching is sound that advocates the duplication of those conditions prevailing during supersedure or the swarming season, such as proper temperature, plenty of nurse bees, and an abundance of food. And it is because of the soundness of that teaching that we use eggs instead of larvae from which to raise queens. Any other method fails in the most essential condition.

CHAPTER V

QUEEN REARING

Preparing the Eggs

The greatest obstacle in the way of using eggs instead of larvae from which to raise queens has been the difficulty in finding an easy and satisfactory method of obtaining the eggs without destroying the combs. While this objection to destroying good combs is quite reasonable in its way, it has, on our opinion, been allowed to carry far too much weight. In the first place it is necessary that combs used for cutting up to provide the eggs, should be tough—the tougher the better—and tough combs are old combs. New combs are more apt to be crushed than cut, and are thereby rendered unsuitable for the purpose. No one cares to destroy useful combs, but in every apiary of moderate size there are always a few old combs that need either repairing or drone comb removed and replaced with worker foundation. This is the kind of comb that should be used. In making over old combs there is a certain amount of labour to be given, and unless

they are replaced by cutting up some other combs, new foundation to be used. We consider it more economical in every way to use these old, tough combs for queen-raising, and to replace them with new foundation. And the cost of providing new foundation is so insignificant as to make the objection on that account quite trivial. Four old combs, allowing a reasonable proportion of each to contain drone comb, will each provide several hundred eggs, and as it costs only two shillings to replace the four combs with full sheets of B.S. worker foundation, it is an economical proposition to use the old combs in the way suggested. Even where it is desired to use new comb to preserve the bright colour of queens of the yellow races, it is profitable, considering the quality of the queens so raised, to use full sheets of new worker foundation in which to obtain the eggs required. Such a sheet when filled with worker eggs could be cut up into half a dozen strips. Each strip would give at least a dozen fine queens, and seeing that a B.S. sheet of foundation costs sixpence, the extra cost of raising each queen by this method is just one-twelfth of a penny. Against that expenditure there is a considerable saving of labour. In using eggs there is no hunting for royal jelly: there is no yearly manufacture of cell-cups: and there is

How!

no delicate operation such as transferring the larvae.

Unless the breeder is operating on a very large scale, the whole of the eggs contained in a comb will not be required at any one time. In that case, the eggs required can be taken and the remainder washed out of the comb with a pint or two of water. The freed comb can then be put away until a couple of days before more eggs are required, when it can be inserted in the brood nest of the queen that is to supply the eggs. Such a queen should be in a nucleus and not at the head of a stock.

The usual method of preparing a worker-comb to obtain eggs for queen-raising, is by cutting the comb in strips on either side of a row of cells containing eggs. These strips are then laid on their sides, and those cells that contain the required eggs are cut down to within one-quarter of an inch from their bases.

After the strips of comb are cut, it is necessary to run a stiff brush—we use an old discarded tooth-brush for the purpose—along the outsides of each strip to dislodge or destroy any eggs that may have been in the adjoining rows of cells. If this is not done, queen-cells will most probably be built on the outside of the proper strip.

The knife used for cell-cutting must be very

sharp and should have as thin a blade as possible. If a good knife is used and the combs are really tough, there is no need to heat it.

After using various knives for cutting the comb into strips, we have found that nothing approaches a Durham Duplex Razor blade attached to a handle designed by the author. With this knife no cells are crushed and the operation is quickly performed.

When the cells are prepared as described, they are attached by wax to a movable bar that fits in a frame retained for the purpose. This frame is of ordinary pattern, having a two inch strip of comb only. The bar carrying the prepared strip is placed immediately beneath the comb in the frame. In this position the eggs are at the lowest edge of the comb, which is the natural position that facilitates the building of the queen-cells.

After the strip of comb is attached to the bar, it was the practice to crush some of the eggs by inserting in the cells a piece of wood slightly less in diameter than an ordinary black-lead pencil. The eggs in two successive cells were thus destroyed, the following egg allowed to remain, the next two eggs crushed, and so on, across the whole length of the strip of cells.

It is now preferred, however, to leave the eggs intact in the cells, and remove the surplus queen-

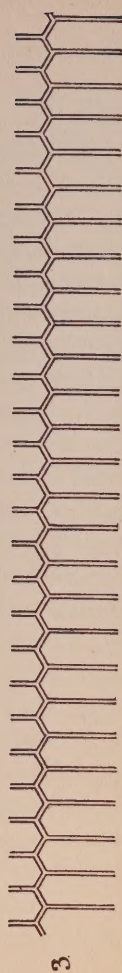
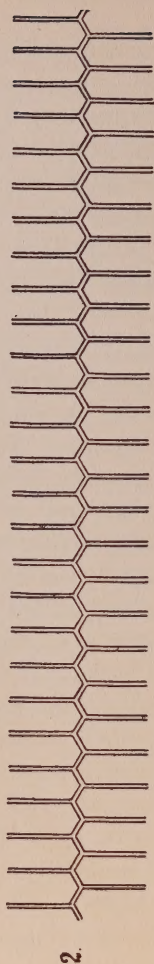
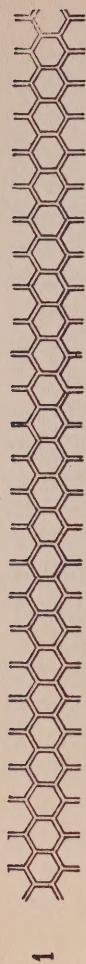


FIG. 1. 1. A strip of cells after being cut from the comb.
 2. Same strip laid flat before cutting one side.
 3. One side of strip cut to a quarter of an inch of the septum.

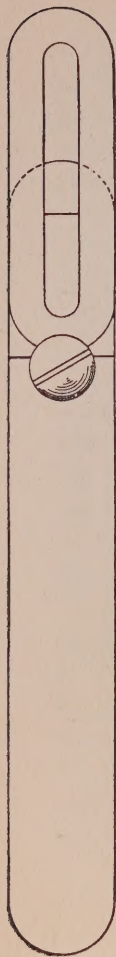
larvae from the cells when removing the latter from the cell-starting colony to the cell-building colony. By removing the surplus larvae instead of the surplus eggs, we achieve several objects: we are able to select cells for size and position; there are less eggs missed by the bees when preparing to start the cells; and the queen-larvae remaining get the benefit of the extra royal jelly that is left in the broken cells after the ejection of the royal larvae.

This method of rearing we consider very effective in the production of really robust queens. There is no possible doubt of the royal larvae receiving food of the right kind and in the right quantity for producing queens of great excellence.

Unless the outside temperature is high, the removal of the surplus larvae should be carried out in a warm room.

The uncertainty of the weather in Great Britain is against the distribution in one operation, of a large number of queen-cells. For that reason and because better results are obtained, it is preferred to raise the queens in small batches of not more than fifteen in a single batch. This number fits in with our "group" system (see Chapter VIII) and tends to simplicity in working.

All operations connected with the preparation of the eggs should be done in a warm and



COMBINED BLADE AND HOLDER



HOLDER (FRONT VIEW)



HOLDER (SIDE VIEW)



SECURING SCREW



DURHAM DUPLEX.
RAZOR BLADE

FIG. 2.

closed room. The operation should be carried out in a strong light, and the atmosphere of the room should be kept moist. This can be done by sprinkling earthen or concrete floors with water, or, in the case of wooden floors, by the retention on the working bench of a large sponge or two saturated with warm water.

It is not necessary for the apiarist who desires to raise queens in small numbers for his own use to follow all the details herein mentioned. Instead of cutting a comb up, he can put a starter of foundation into a frame and give it to a stock from whose queen he desires to raise some virgins. Allow between three and four days for the foundation to be drawn out and filled with eggs, and then remove it to the stock chosen to raise the queens, whose queen had been previously removed. The bees will build queen-cells which will be ready for removal and introduction to the nuclei or other stocks, in about ten days' time.

If the apiarist does not wish to use two colonies to build the cells, he can let the eggs or larvae remain in the first colony that started the cell-building. This is a good practice, and by it some really good queens are produced. In that case the started cells should be examined about five days after insertion of the eggs and the larvae from all above the number of cells required, and a

few to spare, should be removed and the frame of cells replaced.

If frames of brood are added before distributing the ripe queen-cells, it will facilitate the distribution and do much to make the stock contented.

The Cell-Starting Colony

The selection of the colony with which to start the cells is a matter of some importance. It is our practice to reserve the best of the queens whose stocks did not swarm in the queens' first season of headship, the object being to find those queens that may carry the non-swarmling factor. If this factor is possessed by such a stock, it is probable that it will be transmitted. As, therefore, we use eggs from similar queens for queen-raising, we follow the same lines by seeing that the bees providing the royal jelly, which is more than likely a means of transmitting such characteristics, possess the same non-swarmling tendency.

Therefore, we select a colony from among those reserved, and preferably one that has not swarmed for two seasons. This colony is stimulated for early breeding so that a large population of young bees shall be ready for the first batch of eggs.

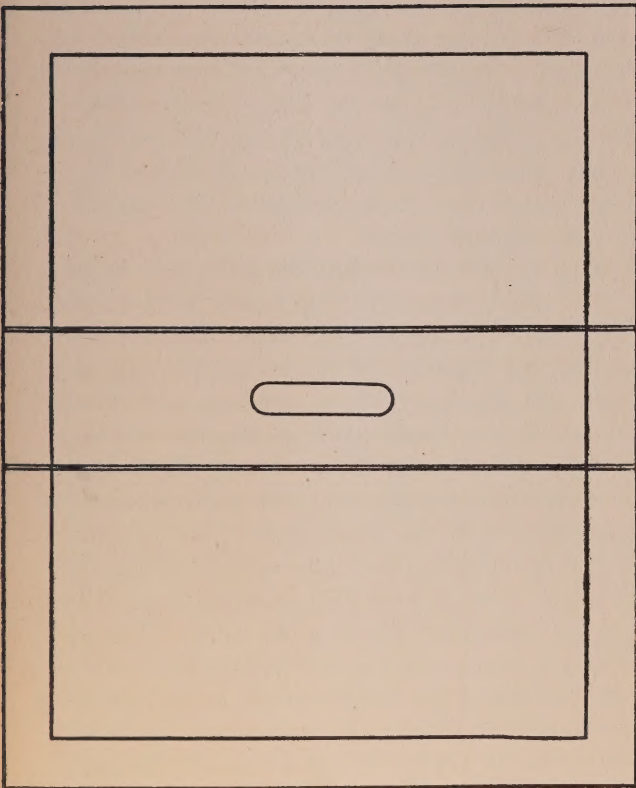


Fig. 3. Tuner cover board for cell-building colony. The centre piece is removable to permit the insertion of the large funnel when forming cell-building colonies.

About three weeks before the time arrives for the insertion of the eggs, the brood and young bees of a similar reserved colony are united to this stock. All the extra brood will have emerged before the time to set the eggs, and the colony will in consequence be very strong in nurse bees.

The cell-starting colony is heavily fed with diluted honey—not sugar syrup—a few days before the eggs are given.

The hive used for starting the cells has a double cover. The inside cover has a removable three-inch strip in the centre. The removal of this strip permits the insertion of the frame carrying the eggs, and also provides an aperture into which can be fixed a funnel used in shaking the bees into the cell-starting hive. When all the bees are in, the strip is replaced, a few quilts are put on top, and over all the outer cover.

The cell-starting hive has two entrances, but both are covered with wire cloth until the bees are released after starting the cells. The entrances are provided for ventilation and to avoid removing the hive from its stand when it is necessary to restore it to its normal condition, as would have to be done if the bottom had a wire screen instead of an ordinary floor board.

The provisioning of the hive calls for particular comment. There is no doubt that unconfined

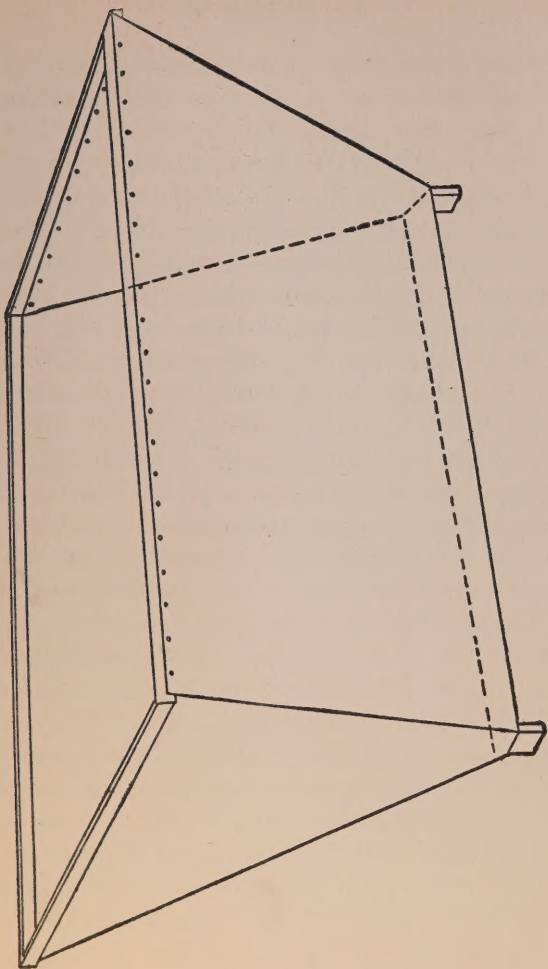


FIG. 4. Funnel for inserting bees into a cell-building colony.

bees do better work at cell-building than those confined. For some considerable time we were at a loss why this should be so. We tried both methods and the nurse bees were well supplied with honey and pollen in each case. After thinking the matter over and observing the greater activity in the unconfined bees compared with other ordinary stocks at a time when no nectar was being brought in, we came to the conclusion that the unconfined bees had one great advantage over those confined, which was the only reason for the difference—namely, they had access to water that was denied to those confined. Since coming to that conclusion, we have known a medical practitioner to say that it is necessary for honey to be diluted with twenty-five times its weight of water before it can be properly assimilated by the human being. Apply this to the bee, and we get some explanation of the tremendous quantity of water consumed by the bees in brood rearing.

Therefore, we always give two frames of water, two frames of uncapped honey, and two frames containing plenty of pollen, the rest of the hive being filled up with empty combs. In this way the bees are provided with all three essentials and unconfined bees have little, if any, advantage over those confined.

The two frames of honey are placed in the centre of the hive with a space reserved between them to receive the frame containing the eggs. This space is arranged immediately beneath the strip in the inner cover.

The queenless and broodless bees are shaken into the hive about ten in the morning, and remain confined until about three in the afternoon, when the prepared eggs are given. They are not fed prior to receiving the eggs, as they were heavily smoked before shaking to compel them to take up the largest possible amount of food.

When the time arrives for setting the eggs, the hive is removed to one side, raised several inches above the ground, and brought down with a thud; this dislodges the bees on to the floor board. The three-inch strip is removed and the frame of eggs inserted between the two frames of honey, the strip is replaced and the hive again placed on its stand.

The three-inch strip of wood in the inner cover has a hole in its centre for a bee-escape. The latter is not used, however, and the hole permits of feeding the bees after the cells are inserted, a seven-pound can of honey with a perforated lid being inverted over the escape hole.

For obtaining economy in both labour and equipment, and to simplify the work, this cell-

starting colony is retained as such as long as the bees continue to maintain the average number of queen-cells from each batch of eggs. The strength of the stock in nurse bees is maintained by the addition of frames of emerging brood obtained from some of the nuclei. On no account must there be any uncapped larvae in these frames, or the bees would start adventitious cells. Occasionally, when some of the nuclei are getting too strong in bees, one or two hives are temporarily removed, the queens found and put on one side and the young bees remaining shaken in front of the cell-starting colony to reinforce it in nurse bees. This is always done before giving a starting colony its second batch of eggs. We find this method much preferable to continuously preparing colonies for cell-starting, and rarely is it necessary to discard a colony for failing to produce its normal output of queen-cells. The brood and queens are then returned to the original stands and when the time arrives for the introduction of another cell, most of the brood will have emerged, and so provide sufficient nurses for the new queen when she commences to lay.

We aim to have each cell-starting colony produce each week two batches of queen-cells, each batch consisting of fifteen cells. As we use eggs

for queen-raising, we allow them to remain longer in the cell-starting colony than would be the case were larvae used. The cells remain for between three and four days in the cell-starting colony.

The queen and brood from the cell-starting colony are utilised elsewhere.

As the cell-starting colony is not removed from its stand particular attention is given to shade.

In removing the cells from the cell-starting colony to the cell-building colony, most of the adhering bees are carefully brushed off the cells into their hive. It is not necessary to remove every bee as the cells are to be inserted into another queenless colony—the cell-building colony—and bees in that condition can be exchanged at almost any time. On no account should the frame carrying the started cells be shaken or jarred; otherwise there is a great possibility of dislodging the young queen-larvae, thereby nullifying all the previous work. Even where the queen-cells are sealed, the adhering bees must never be shaken off, for the queen-pupa is a very delicate creature and easily injured.

The Cell-Building Colony

This, like the cell-starting colony, is stimulated for early breeding. About three weeks before this hive is due to receive the started cells, it is

reinforced by the addition of the young bees and brood from another strong stock, the queen of which, with a couple of frames of brood, is left on the old stand to build up.

These colonies are united in the ordinary way by the newspaper method, and the day before the started cells are given, the brood is rearranged so that all the older brood is put in the upper chamber, and the younger in the lower. The queen is confined to the lower body by an excluder. Before putting on the latter, however, the bees on the frames in the upper storey are shaken into the lower storey in case the queen should have gone above. The frames of brood placed in the upper chamber should be examined for queen-cells, and in replacing the frames, space should be left in the centre to take three frames: one frame of uncapped honey, one frame of unsealed larvae, and the frame carrying the started queen-cells.

Eventually the upper storey of the cell-building colony will be raised well above the brood chamber, consequent upon having surplus stories put between the two chambers. When that takes place, we prefer to provide a separate entrance for the bees in the cell-building chamber.

So that the population of nurse bees will be maintained in the upper storey, the brood is con-

tinually reinforced similarly as was done with the cell-starting colony; by adding frames of emerging brood from other hives.

One such cell-building colony is prepared for every cell-starting colony, and takes all the cells started by the latter. The cells remain for one week in the cell-building colony, and as the cell-starting colony produces two batches of cells each week, the building colony will always be in possession of two frames of cells, after the insertion of the second batch.

When the second frame of started cells is placed in the building colony, the frames are rearranged. A frame of unsealed honey occupies the centre of the chamber; on either side are two frames of cells, and outside these, two frames of unsealed brood. The remainder of the chamber is filled with frames of emerging brood.

When additional frames of cells are given, the frames of unsealed brood are carefully examined for adventitious queen-cells, which are removed, and other frames of unsealed brood inserted as necessary.

When no nectar is coming in, the building bees are fed.

Twice a week a frame of completed cells is removed for distribution among the nuclei, and to provide space for the embryo cells from the start-

ing hive. To save time and unnecessary manipulating of combs, the frame of cells next for removal from the cell-building colony is marked by a small drawing-pin pressed into the top bar. When the frame carrying the pin is removed, the pin is transferred to the other frame of cells remaining in the hive, and thereby indicates the exact frame of cells for removal on the day when the frames are again changed.

Time-Table

In bee-breeding on a commercial scale, the one essential is system. By it the various operations are made almost automatic, with the result that the possibility of confusion arising is reduced to a minimum, if not entirely prevented. The breeder is also relieved of a considerable amount of head work, and is thus enabled to concentrate on more important points that are fundamental to success. With the object, therefore, of systematising breeding operations, it is advisable that certain days be reserved for certain manipulations. A system found to be satisfactory is given below.

On Mondays and Thursdays mated queens are removed from the nuclei to the "reducing" nuclei in a shed. These last mentioned nuclei will presently be explained. The queens are not removed in the case of untested queens until

there is sealed brood in the nuclei from the young queen. When queens are being tested, they remain in the nuclei until some of their brood emerges and the mating can be checked.

On Tuesdays and Fridays completed queen-cells from the cell-building colony are distributed among the nuclei whose queens were removed the previous day. In the meantime, the nuclei are fed unless honey is coming in.

When the cell-building colony is clear of its completed cells, the frame of embryo cells in the cell-starting colony is transferred to it, and takes the place of the cells removed.

Comb is then cut to provide eggs for as many cell-starting colonies as there are in use, and on the next distribution these prepared eggs will take the place in the cell-starting hive of those cells transferred to the cell-building colony. This rotation of work is continued throughout the season.

On all these manipulations taking place, both the cell-starting and cell-building colonies receive whatever emerging brood is necessary to maintain the nurse bees in good strength.

Nucleus Hives

The nuclei for mating purposes can be formed in any hive having a capacity of ten frames. One

frame is removed and the hive is divided by division boards into three separate compartments.

Our division boards are not fixed and have at their bottom edges two-inch double strips of queen excluder zinc. Where strange bees are used for each separate compartment, it would be necessary to have each compartment both bee and queen tight. Where, however, the divisions are made from the one colony, there will be no fighting when the bees have access through the excluder zinc to the different part of the hives.

The loose division boards facilitate uniting at the end of the season, and the zinc strips make for better ventilation.

Each nucleus hive has three entrances and work is carried out on the blind side. No entrance is centrally placed on the side or at the end of a hive. This permits the hive being divided into two equal compartments where it is desired to winter two nuclei in the same hive.

Each nucleus has a separate cover, so that one nucleus can be manipulated without interfering with another.

Provision for feeding the nuclei is made by means of bottle feeders and holes in the inner cover.

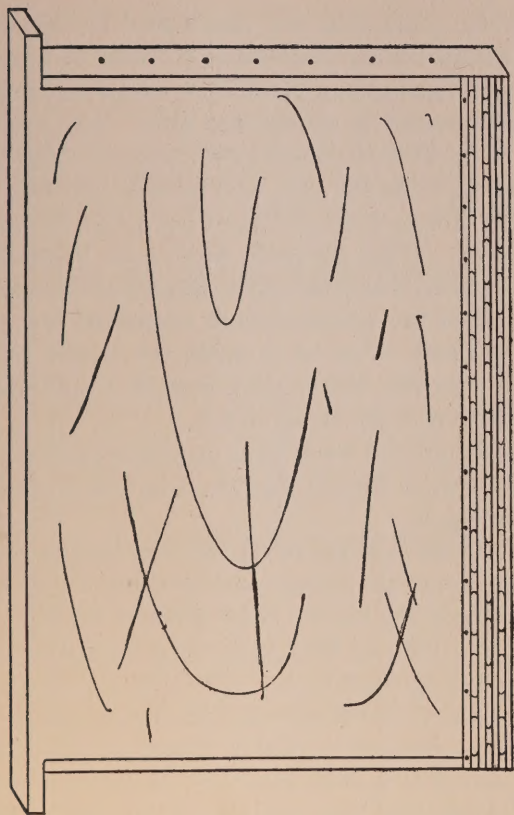


FIG. 5. Division board with queen-excluder at the bottom: only used where a strong stock is divided to form nuclei in the same hive.

Introducing Queen-Cells

When queen-cells are distributed among nuclei without being attached to a frame of brood, they are carried in a block of wood having holes bored through it on the flat side. The under side of the block is covered with mosquito netting, which supports the cells and permits warmth to ascend from a stone bottle of hot water beneath the cells. This prevents any cells becoming chilled when it is necessary to introduce them at a time when the temperature is somewhat low.

The block of wood is made the length of a frame and fits, like a very shallow frame, into a hive of half the usual width.

Nuclei are fed when their queens are removed, and also when the cell is given, if no honey should be coming in.

When the cells are ready for distribution, they are cut from the frames and each cell is put into a hole in the block. Each nucleus readily accepts the cells as they have been queenless for about twenty-four hours. The cell is placed on the inside of the frame nearest the entrance, in which position it is quickly found by the bees, and attached to the comb by pressure. It is preferable that the comb to which the cell is attached should contain brood.

The half-size hive used for carrying the cells

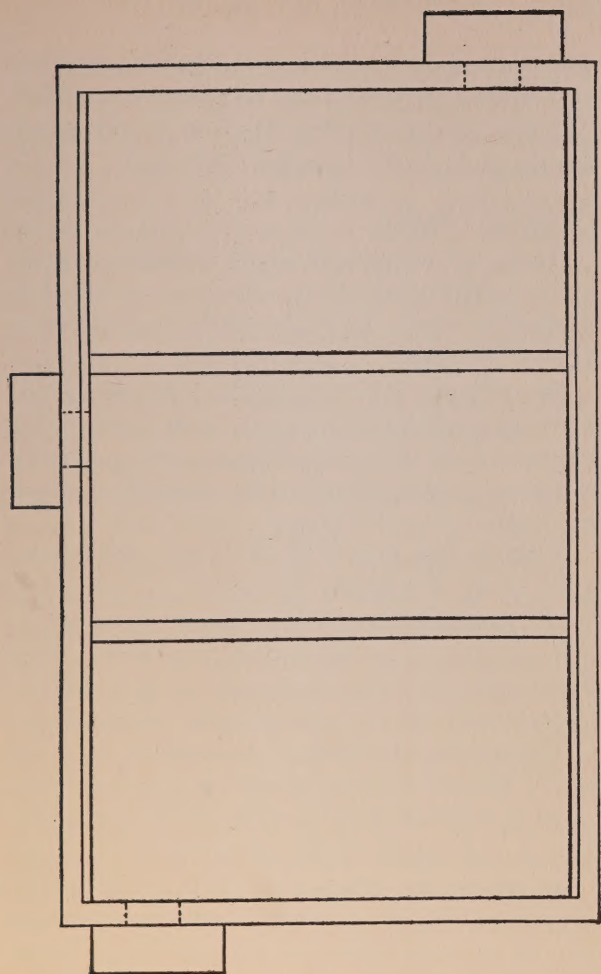


FIG. 6. Nucleus hive showing how the entrances are placed.

when introducing, is also employed in carrying any frames of brood from one place to another. The hive is made of extra depth to provide space for the stone bottle beneath the frames.

“Reducing” Nuclei

These are one-frame nuclei containing brood and a newly mated queen. They are retained in a shed in which they are marked and, where wanted, clipped.

The object of these nuclei, besides making the marking and clipping easy in more comfortable circumstances, is to permit the queen to gradually reduce her egg laying before dispatch through the mails.

Each nucleus-hive in the shed has a small hole, covered by a one-hole piece of zinc excluder, which permits any old bee to leave the nucleus and return to its old nucleus outside. This hole opens into the shed—not to the outside. Thus there is no fear of the nuclei being robbed.

In selecting the frames of brood to form the nuclei, those are chosen which contain a good proportion of brood, and, preferably, those containing about a couple of pounds of food.

As queens are called for to fill an order, they are taken from these nuclei. As the latter lose their queens, the queenless bees with their brood

are put into a hive body which, when completed with frames, is taken outside and the young bees shaken in front of one of the cell-building colonies. The frames of brood are then placed on a hive running for extracted honey. If the honey flow is reaching its end, these combs of brood are given to the field bees of a stock that has been removed to another stand. In the latter case a queen is reserved from among those in the shed and given to the new stock.

The reducing nuclei are kept supplied with queens from the outside nuclei as the queens become ready for removal.

When a queen is removed from an outside nucleus a piece of white celluloid is fastened with a drawing-pin to the frame carrying the queen. On this piece of celluloid is recorded the number of the nucleus from which the queen came and this number is copied on the cage in which the queen is inserted to fill an order. Black-lead being used to record the number on the celluloid, the latter can be repeatedly used for the purpose after removing the old number.

In all manipulations of nuclei where the bees are confined, it is absolutely essential that provision be made for an abundance of fresh air. This can be arranged for by tacking a piece of hessian of fairly open weave to a wooden frame made the

same size as the nucleus it is to cover. In a hive carrying several nuclei, such a frame should be made for each nucleus. These frames are placed on the nucleus-hive with an empty super placed above them. Should the bee-keeper be raising, say, half a dozen queens yearly for his own use, it would pay him to keep a special brood chamber with a fixed floor-board for queen-rearing operations. Such a chamber should have two-inch holes in the floor to correspond with the nuclei, and these holes should be covered with perforated zinc. With a chamber fitted in this manner there is no possibility of the bees being smothered. The chamber can be used as a swarm box, or for any temporary purpose where a chamber is required.

CHAPTER VI

THE CONTROL OF MATING

The Problem Stated

The control of mating is one of the greatest problems in bee-breeding. The haphazard mating of the bee is the open door through which an influence can enter that can nullify much of the breeder's work. He can take steps to control the drones of his own apiary, but, through the peculiar method of the mating of the bee, he is at the mercy of every foreign drone, no matter what the source of origin, nor the race to which it belongs.

The solution of the mating problem will not be found in drone control only, in so far as that control relates to preventing drones flying.

Some Probable Solutions

Much can be done in this matter by the selection of breeding queens, especially for breeding drones, from among those queens that have shown a propensity for raising drones in limited numbers. This is a matter that should receive more

attention than has hitherto been accorded it. Undoubtedly there is a wide difference in queens in this matter of drone-raising, and that difference is an indication of a means by which improvement in mating is both probable and possible.

But the mating problem is one that by its very nature cannot be solved by any single individual, since there are predominating factors over which he has no control—the drones of other bee-keepers. Therefore, it is a problem that demands the co-operation of every bee-keeper in its solution.

Drone Control and Other Problems

The fact that drone control is beneficial in other directions and for all apiarists, makes its solution one that should be attempted by all. Not only has it a distinct bearing on the swarming problem, but also on the spread of disease. Bees will tolerate the entry and residence of any drones during the gathering season. These drones are likely carriers of disease and a restriction in their number would do much towards reducing the possibility of it spreading. There is also the extra consumption of food to be considered, where a large number of drones is needlessly raised.

In making the suggestion to restrict the breed-

ing of drones, we would not have it thought that we are advocating their entire suppression. In the season of activity, it is part of the natural life of the bee to have drones in the hive. This is a natural precaution, since there can be no knowledge of what the future may bring forth. With drones present the bees are prepared for any happening that may necessitate the raising of a new mother, whether by swarming or by supersedure.

The bees' natural instinct in this matter should not be thwarted by man. To succeed in the complete suppression of the drone would actually result in the obliteration of the bee itself.

A possible effect that may arise from breeding to reduce drone production, is a likely increase in quality as the number of drones was reduced. A colony that had to rely on the presence of a couple of dozen of drones would probably care more for their big brothers than would be the case where a couple of hundred were available.

It might be inferred from what has been said that we believe the queen to be mated with drones from her own hive. Undoubtedly she is occasionally so mated, but as a general thing, no! If it is otherwise, how can the large number of mismates be accounted for?

Combined with the systematic breeding effort

to reduce the production of drones, there should be every effort towards increasing the stamina of the drones where they are actually required for breeding purposes.

Control of Drones by Mechanical Means

Until the breeder has improved his strain on the lines indicated, he must fall back on drone control by mechanical means. This consists of compelling the unwanted drones to remain either in the hive, or outside the hive when once they have flown.

The latter is the method we prefer, since by letting the drones fly and blocking the original entrance with queen-excluder, we are working to control swarming through plenty of ventilation.

To achieve this an entrance at the back of the hive should be provided, and the front entrance closed with wire-excluder, in preference to zinc. The drones finding their liberty restricted to the back entrance will leave by that, but return to the front. When they become chilled they can be swept up and put into a bucket of water. As the season advances, it may be necessary to close the back entrance with the excluder as well. If these strips of excluder are fastened with long-shanked drawing-pins to the hive, very little time and labour are employed.

The method of restriction just described is preferable, in our opinion, to the practice of providing nuclei with a quantity of drones. Our aim is to have a large number of drones in a few very strong colonies which are called upon for nothing but the feeding and care of their drones. In this condition we are certain of the drones being well reared and well mothered up to the time they are no longer needed.

If, on the other hand, a small number of drones is placed in the mating nuclei, there is no certainty that the feeding will be sufficient to support the vigour of the drones.

The Quick Disposal of Drones

Another point worthy of remark, is that the drones, when restricted to a few hives, are under greater control. If it should be necessary for some particular phase of breeding to fly two kinds of drones in any one season, it becomes an easy matter to dispose quickly of the drones no longer wanted.

This is carried out by finding the queen in the colony having the drones to be got rid of. Any drones that may be on the frame of brood on which she is found, are flicked off and they re-join the bees in the brood chamber. The frame of brood with the queen is then placed into a

spare body completed with empty frames. This chamber having the queen is then placed on an excluder above the old brood-nest in which the whole of the drones are contained. Towards dusk or when the drones have ceased flying for the day, the position of the chambers is changed. This will bring the old queen below the excluder, and make the drones prisoners above it.

Controlling the Drones by the Use of Nets

It will be gathered by what has been said that we have no faith in the use of netting to restrict mating. This has been tested with only partial results; but apart from that, the provision of netting would be a serious addition to the cost of producing queens, and the nature of the netting used would make renewal a frequent necessity; one heavy storm alone might be sufficient to wreck the whole concern.

In this matter of control the apiarist who wishes for purely mated queens for his own use only, is in a more fortunate position than the commercial breeder. The latter must have queens continuously mated throughout the season. The former can choose his own time when success is almost a certainty. That time is at the end of the season when foreign drones have been killed off. When the latter process commences the queen at

the head of the drone-breeding colony should be removed, and the colony so made queenless fed every day. When the young queens have been mated either the old queen or one of the newly-mated ones can be given to the drone-breeding colony.

Checking the Matings

The methods employed in checking the matings of queens depend on the purposes for which the matings are made, and on the varieties of the races used.

If the breeder were mating to ascertain the extent to which Mendelian principles operated with the bee, elaborate methods may be necessary. Similar methods would probably be also required where two races, each of a distinct and different colour, were crossed.

In the crossing of the black races, we have found the use of a powerful hand-glass to be quite sufficient for the purpose.

In this matter of checking the matings we have been greatly helped by the fact that the bands on the abdomen have been intermediate in character to those carried by the parents.

In using a hand-glass for this purpose, we have found no necessity to remove bees from the comb. A comb of brood on which a number of newly-

emerged bees is parading, is simply lifted up from the brood nest and held so that the light shall fall directly on them, when the mating can be ascertained by their markings.

Where there are many bees in the neighbourhood with similar markings, it is possible to make a mistake in deciding whether the queen has been correctly mated. In this matter the apiarist should be assisted by the intimate knowledge he has of the behaviour of his own strain. Accuracy is more important where the queens under check may be eventually selected as queen-mothers. In that case, however, the apiarist would have one complete year in which to discover any characteristic that differs much from those possessed by his own stock.

If, on the other hand, the queens are under check for the purpose of discovering drone-mothers, the breeder need not be so exact, as the crossing of the queen by an outside drone would not influence the drone progeny nearly so much as it would the worker or virgin-queen progeny. At the same time there should be no necessity to use such mated queens as there will be others of the group known to have been correctly mated. The characteristic that is particularly necessary to watch when checking for drone-mothers, is disposition.

Artificial Mating

The desire to gain control of the mating of the honey-bee has resulted of late years in a fair amount of experimentation in artificial mating, and some success seems to have been achieved. Apart, however, from the utter indecency of the process, we must confess our inability to see the utility of such mating. It is an operation quite beyond the ordinary apiarist, and, therefore, one that is restricted to the scientific experimenter with much time on his hands, and a great desire to be clever enough to dispense with nature.

It is, moreover, an operation that is necessary with every virgin and, therefore, one that would certainly raise the cost of queens so mated. With the increased price the purchaser would have a very doubtful bargain. It is certain that, by the insertion of an instrument into a certain part of the queen's anatomy, there could not fail to be, in a very large number of cases, some injury to the queen in some way. Furthermore, there is no actual necessity for such an operation. The breeder who desires to be positively certain of queens mating to a particular strain of drones, can have them so mated by a little extra trouble. All he has to do is to preserve his own special drones until the ordinary drones are killed off in the early autumn and then fly his virgins.

To us, the whole conception is repulsive, and we do not hesitate to condemn it most thoroughly. If more attention were given to practical breeding methods and investigators showed their breeding ability by working in conjunction with nature instead of against her, apiculture would certainly benefit and those investigators be greatly honoured. We believe that the true solution to such problems can be arrived at only by man co-operating with nature; but directing her into channels within her own province for his future profit; and by proceeding only so far in that direction as shall not upset the balance of her forces.

CHAPTER VII

MATING NUCLEI

Reasons for Their Use

If the queen-cells remain unprotected up to the time when the first virgin emerges from her cell, they are most likely to be destroyed by the virgin unless she is prevented by the worker bees from so doing.

It is necessary, therefore, to provide separate accommodation for each queen-cell that has been raised. This is done by forming nuclei, which serve the double purpose of providing accommodation for the ripe queen-cell, and a mating hive for the young queens.

Forming Nuclei

In forming nuclei by removing bees from one hive to another, the apiarist has to guard against two things: the bees deserting the nuclei, and putting bees in the nuclei insufficient in numbers to protect the queen-cells and brood against variations in temperature. The former can be pre-

vented to a great extent by making the stock to be broken up queenless two or three days before the actual forming, and then confining the bees in the nuclei when the latter have been formed. The bees so made queenless and used for making nuclei are not so apt to return to their old home site. Insufficiency of bees for brooding purposes can be avoided only by increasing the proportion of bees to the amount of brood given to each nucleus. In the fickle climate of Britain nothing is gained by attempting to use small nuclei for mating purposes. Naturally, the bees of whatever number will endeavour to protect both queen-cell and brood, but they can do that thoroughly only when their numbers are sufficient for the double purpose. If the nuclei are weak in bees, chilled brood will result, and the emergence of the queen will be delayed.

Nuclei, temporarily formed for mating purposes only, do not require a large amount of brood, the only function of which is to make the bees more contented and to attract them to their new home. A single frame of brood is ample for the purpose and requires fewer bees than is the case where more frames of brood are employed.

There are several methods of forming nuclei. They can be formed by breaking up a colony in-

to separate parts according to its strength. If the old queen is no longer required, she can be destroyed, but if it is desired to retain her, she should be removed to a new stand three days before making the nuclei. With her should go the bees and the frame of brood on which she is found, together with the bees from another frame of brood. She should also have one empty comb and one comb of honey. The nucleus should be confined and released on the third day.

Three days after the removal of the old queen, nucleus hives, each containing one comb of uncapped honey, are set out on new stands with the entrances closed with wire screens. The remainder of the colony to be broken up is then divided by shaking a frame of bees into each nucleus hive, which also receives one frame of brood and bees and a ripe queen-cell. The hives are contracted by the use of division boards, and the bees are confined for three days, being released late in the evening of the third day. The beeless brood left over after forming the nuclei can be placed upon another colony.

For providing the necessary ventilation, it is advisable to have the whole width of the entrance covered with wire screen, and when releasing the bees after their confinement to contract the

entrance as a prevention against the attacks of robbers.

The Most Suitable Bees for Forming Nuclei

Partly to overcome the difficulty of preventing bees returning to the old home site, and thus deserting the nuclei, and also to obviate the breaking-up of colonies with which to form nuclei, it is preferable to use either young bees that have never flown, or bees, as previously suggested, that have been queenless for several days, or a combination of both. Young bees are the most desirable for the purpose, since they know no other hive, and consequently remain in their new home. In addition they are procurable at the most suitable times for successful mating—not too early or too late in the season—without detriment to the colony from which they are taken.

In a former place we suggested that the apiarist rearing his own queens, should provide only one colony both to start and to build the queen-cells to completion. In that case the better plan would be to use the young bees in conjunction with those that built the queen-cells. Most of the latter will be field bees, but owing to their lengthy queenless condition will not readily desert the nuclei. In addition they afford the needed pro-

tection to the nuclei which frequently become easy prey to robbers.

The method that dispenses with the actual breaking-up of colonies other than those used in cell-building and that makes use of young bees, is the following:

About a week before the time arrives to distribute the queen-cells to the nuclei, a very strong colony is selected to provide the young bees required. When most of the field bees are foraging, this colony is removed from its stand to a situation well away from the old site, and in its place is put an empty hive. Find the old queen and put her with the bees and frame of brood on which she is found into the new hive on the old stand. Fill up with empty combs, and if nectar is still coming in, replace the supers and excluder, if one is being used.

Contract the entrance and allow the old and now queenless hive to remain where first placed for an hour or two. This will permit all the field bees to leave the brood nest and return to the old queen on the old stand. When free of the old bees, take the queenless division and unite it by the newspaper method to the cell-building colony. Make a dozen holes in the newspaper with a black-lead pencil, the object being rapid uniting and the provision of ventilation. Invert a seven-

pound can of diluted honey over the feed hole in the inner cover of the upper storey. When united in this manner, the colony will be in two stories, with brood in the upper and the queen-cells in the lower.

Providing this method is used between the middle of June and the end of July, nothing necessary to the gathering of surplus honey will have been removed from the colony giving the young bees. In fact, that colony will have benefited by the removal of the brood and young bees, since it has been relieved of the necessity of feeding them.

The Disposal of Natural Cells Found When Uniting

When uniting, the frames of brood must be thoroughly examined for queen-cells. If the apiarist is breeding his bees in the orthodox manner, he should destroy any queen-cells so found; but if he is line-breeding his bees in a manner similar to that advocated in a later chapter, and the cells do not exceed four in number, he should make nuclei of the young bees and distribute these queen-cells among the nuclei so formed. These cells are supersedure cells and being from line-bred bees should be retained.

If supersedure cells are found, young bees to form the nuclei for the artificially-raised queen-

cells, will have to be obtained from another hive.

Rearranging the Hive

The day before it is necessary to distribute the queen-cells to the nuclei, we must rearrange the hive containing the queen-cells and brood. By that time the bees will have peacefully united, and our object now is to get all the bees, brood, and queen-cells into one body.

Before we do this, however, we must consider whether we are to raise more queen-cells or not. If we require no more cells than those ready for distribution, we can use the bees in the united colony to form our nuclei. If, however, we need another batch of queen-cells, it will be advisable to leave the bees of the united colony to raise other cells, and use young bees from other colonies to form the nuclei. For the purpose of raising more queen-cells by the old cell-building colony, there will be an abundance of young bees—some that came as such when uniting, and others that, in the meantime, have emerged from the brood united to the old cell-building colony.

No Loss of Surplus Honey

It will be observed that this method is very suitable for the apiarist who desires to raise his

own queens, and at the same time obtain the largest amount of surplus honey. To him the breaking up of gathering stocks is a serious matter, for by so doing he loses the surplus they would otherwise give him. For raising all the queen-cells he requires, and taking advantage of the bees and brood that are of no use to the gathering colonies, he has to use one colony only that will give him no surplus. Even that loss can be avoided if he will form his cell-building colony entirely from young bees obtained from gathering stocks.

Distribution of Queen-Cells

Assuming then that no more cells are to be raised, a floor-board is provided and set down beside the cell-building colony. On it is placed the upper chamber containing the brood. The lower storey is moved away and in its place is put the upper storey with the brood. From the latter is removed one frame of brood, which is temporarily set to one side. The frame of cells is taken up, most of the bees are gently brushed off, and the frame inserted into the space previously occupied by the removed frame of brood. This is to protect the cells while they are being cut out and one cell attached to each frame of brood. The removed frame of brood is similarly treated,

and returned to the hive, which is then covered up. The bees remaining in the old chamber are shaken in front of that having the brood and cells. Each of the frames of brood, with its bees and queen-cell, and with the addition of a frame of honey, will form a nucleus.

If care is not exercised in the distribution of the frames, many bees will fly and be lost to the nuclei. Therefore, we try to avoid doing anything that will cause an extensive flight.

To that end we arrange the stands for the nuclei, but take the nucleus hives to the colony with the queen-cells. The nucleus hives having their entrances closed with wire screen, are given a frame of honey, one frame of brood with the adhering bees, and the queen-cell. The hive is then closed and gently carried to one of the stands.

The nuclei remain confined for three days and are liberated late in the evening of the last day of confinement.

Before the cell-building colony is divided, frames of brood should be substituted for any broodless combs in the upper chamber, and the chamber filled to its capacity with the former. If the queen-cells are in excess of the number of frames of brood so provided, one frame nuclei with no brood, but with plenty of food, should be

formed and placed in some sort of building which is cool and dark. By this arrangement interference with other hives to get the extra bees and brood is avoided. The broodless nuclei should receive about a pint of bees, which can be obtained from the united colony. If, however, it is preferred to supply all nuclei with brood, another hive must be called upon for the extra brood required.

Relative Position of Professional and Amateur Breeder

Although we can form nuclei and get our queens mated without the breaking up of colonies, the apiarist who breeds his own queens is greatly handicapped by the need of providing extra hives in which to form the nuclei.

The professional breeder is not so situated. He has his equipment and makes nuclei at the beginning of the season for the special purpose of producing mated queens, from the sale of which he obtains recompense for his labour and his invested capital.

The ordinary apiarist, on the other hand, is almost invariably without the necessary equipment and depends upon honey production for his profit. It is essential, therefore, that he does nothing that will adversely affect that produc-

tion. If he interferes much with his colonies before or during the honey flow, he will either do much to reduce the surplus, or give himself a great deal of work in moving supers and bees.

Therefore, he should arrange his breeding operations towards the tail end of the honey flow, and in such a manner that all his queens will be mated not later than the middle of August. By this arrangement the queen-larvae get the benefit of natural food, and there will be ample time in which to have the young queens mated and produce large brood-nests before closing down for the season.

In this matter of mating the problem confronting the honey producing apiarist is how to overcome the deficiency of equipment, i.e., hives, in which to form the nuclei. Fortunately, the problem is easily solved.

A Method for the Amateur

Where nuclei are formed for mating purposes towards the end of the season, it is not only unnecessary but also undesirable to move either bees or hives, much less break up colonies.

In our considered opinion it is far preferable to divide a colony on the stand it occupies by the use of division boards. This saves the labour of preparing new stands and distributing the bees:

calls for no equipment other than the division boards and the necessary blocks of wood to make the bee-tight divisions, and simplifies the re-uniting of the nuclei when mating has been accomplished to the removal of two division boards: assuming, of course, that each colony was divided into three nuclei.

A favourable point about this method of nuclei forming is that it is suitable for both the commercial man and the ordinary apiarist. The former can use the nuclei throughout the season from the stands on which they passed the winter. The latter can use any hive immediately after the honey flow, or, if he is desirous of obtaining some queens mated to his own special drones, after the majority of ordinary drones have been killed off.

There is, however, another advantage by the use of this method at the time suggested. It provides an opportunity of carrying an extra queen or two over the winter, by forming, or reducing to, two nuclei in each hive. In that case only one division board would be withdrawn, and the other moved towards the centre to divide the stock more evenly.

If this method is adopted, the procedure would be as follows: Find the old queen and make a nucleus with her on a new stand. Give her one

frame of brood and sufficient bees to cover that and another frame: also a comb of honey, one empty comb and a division board. Confine the bees.

Assuming that the hive is of ordinary ten frame capacity, and that three nuclei are being formed in the one hive, arrange the young and uncapped brood in the nuclei that will use the new entrances to be provided. This brood will attract a good cluster of young bees there and thus balance the population in all three nuclei. Extra entrances must be provided—one for each nucleus—as far apart from each other as possible, so as to lessen the risk of a queen returning to the wrong entrance.

Allow the queenless colony to remain in that condition for three days, feeding it in the meantime. On the third day insert two division boards, removing one of the ten frames to do so. See that three absolutely bee-tight divisions are made, and pay special attention to the space under the lugs of the division boards which must be closed so that no bee can pass from one nucleus to another. When the hive is prepared insert a ripe queen-cell in each nucleus by pressing it gently in an empty space of comb near some brood. Cover up and feed each nucleus through a slow feeder.

There is no necessity to confine the nuclei so made as the bees are in their own hive on the old stand.

Introducing Queen-Cells to Full Colonies

The novice at queen rearing may feel inclined to introduce queen-cells to full colonies. This is a practice to which, when carried out in the ordinary way, we do not agree. There is in the first place, too much trouble in finding the old queen, and if the introduction is to be made during the honey flow, there is the additional trouble of removing the supers. If made later in the season, then it is done at a time when the bees are not on their best behaviour. In the second place, should the cell be torn down by the bees, or the queen fail to return after mating, the colony will receive such a set-back as almost to ruin it.

The apiarist, however, can successfully introduce a queen-cell to a full colony if he will use the author's method of queen introduction. In that case, however, it is essential that the cell be given attached to a comb of sealed brood carrying bees. Even should disaster overtake the young queen when mating, little damage will have been done as the old queen will still be there to tide the colony over until another queen is procured.

Virgin Queens and Nursery Cages

The introduction of virgin queens to nuclei entails the provision of nursery cages to accommodate the queen-cells until the young queens emerge therefrom. This is a practice that we unhesitatingly condemn. We know from experience that queens that have emerged in nursery cages are never so good as those that emerge in freedom among the bees. And the reasons are not far to seek. A queen-cell in a nursery cage cannot be properly brooded by the bees. It is essential that the bees come in direct contact with the cell, as only by so doing can the cell receive the proper protection against a lowering of the temperature necessary to the continued and perfect development of the cell-inmate.

Further, queen nursery cages are provisioned with candy, which constitutes the only food of the virgin after emergence until she is released from the cage.

This is in direct opposition to the natural requirement of the young queen. During the period between emergence and the first flight, she consumes honey and pollen, the latter in comparatively large quantities, and if it is remembered that pollen is the source of the nitrogenous food required by the virgin queen, it will readily be seen how a queen deprived of that essential

can never be so robust as another that has been naturally fed from the first.

We should like to draw attention here to a statement that we believe to have no foundation in fact. Very frequently it is asserted that the virgin queen is fed by the nurse bees. This is something we have never seen, and in this matter our experience agrees with that of others, who have looked for this feeding but have never seen it take place. Certainly the evidence here is only negative, but, on the other hand, not one single bit of positive evidence that the nurse bees have been actually seen to feed the virgins, has ever come to the author's notice. The young queens must obtain their nitrogenous food from some source, and if they do not receive it from the nurses, they must, of necessity, get it from the only other source—pollen.

It is possible, however, that where virgins emerge into nursery cages, one of the virgins may be fed, as it is well known that bees will frequently cluster round one cage and totally neglect all others. In that case, however, the feeding would be consequent upon the artificial conditions in which the young queens are reared. Therefore, that instance of feeding could not possibly be accepted as indicative of what takes

place when the virgin emerges under natural, and, therefore, totally different, conditions.

The Care of Queen-Cells

A matter of some importance is the care of queen-cells. Frequently one sees in journals of foreign origin photographs showing queen-cells fully exposed to the atmosphere. Those photos are apt to give a totally wrong impression, unless it is remembered that the climatic conditions of those countries are much more favourable than those of this country. Such exposure may not do harm where the temperature is 90° in the shade, but in this country those conditions rarely exist, and cells cannot be played with in the same manner.

Necessity of Warmth

Warmth is essential to all young, and we look upon the period of incubation between the hatching of the egg and the emergence of the young queen as being identical to the period in which the young of the mammal is undergoing development within its mother; in other words, the period of brooding of the bee-larvae is equivalent to the period of gestation in the mammal.

The author is totally opposed to what are

termed "baby" nuclei. The great need of the inmate of a queen-cell, especially just before her emergence, is warmth, and in this climate we can be sure of such warmth only when the cells are cared for by bees in large numbers. Where nuclei, consisting of three or four standard frames, are used, the proper conditions for brooding are present, and the development of the queen is not retarded in any way.

The queen-cell, as is well known, has its sides of a porous nature, which permits the inmate to receive fresh air. But that air must be warm, and it is by direct contact with the cell that the bees are able to provide the warm air necessary. This is following nature closely, and is one of the factors that go to make the naturally-reared queen superior to that raised under artificial conditions. The correctness of the temperature surrounding the queen-cells is a matter of vital importance. A reduction of temperature prolongs the incubating period, reduces the size and capacity of the queen, and if excessive, causes the young queens to emerge with some deformity. And the reason the queens are not incubated properly when those contrivances are used, is, we believe, due to the bees' dislike of metal.

The Spiral Cell-Protector

The spiral cell-protector is put over the cell in a cold state and the wire attracts warmth from both within and without the cell to the detriment of the inmate.

Apart, however, from its adverse influence on the queen, the spiral protector is, in our opinion, a positive snare. While the young queen is in the cell, the protector does fulfil its function; but if the bees are intent on refusing the cell, they will not hesitate to destroy the queen when she emerges. The apiarist is here misled. He examines the cell and, finding its mouth to be open in the usual manner, rightly concludes that the queen has emerged. But he has nothing to tell him that the queen has been destroyed, and he naturally thinks that she is still there, only to discover later her absence. He then further concludes that the virgin was lost on her wedding flight; but had the cell been without its false protector, it would have carried evidence of what had actually happened, and the apiarist would have known exactly and at once the true position.

The Care of Nuclei

It is fundamental to keep the nuclei in a pros-

perous condition. There must always be plenty of food in the hive and some always coming in. If food does not come in by natural means, then the apiarist must resort to feeding. Neither should the nucleus ever be without brood.

Brood and food in the hive make it a home worth defending, and constitute the means, next to a fertile queen, that make for contentment. Should the nuclei become unbalanced in brood and honey, exchanges must be made to bring both to the same level.

Whenever there is a cessation of the honey flow, special precautions must be taken when manipulating. At that time robbers are on the alert and such a small body as a nucleus becomes easy prey to such. It is, therefore, advisable to restrict all manipulation to the evening, which is also the best time to give the necessary food.

If robbing takes place we find the best procedure to cover the robbed hive with a sack of open weave that has been cut away at one side and the bottom to make a bigger cover. These sacks are also used to shade the hive and are always available.

The nuclei should be examined on the ninth and seventeenth day after the estimated day of emergence of the young queens. If on the first examination the apiarist finds no eggs or larvae,

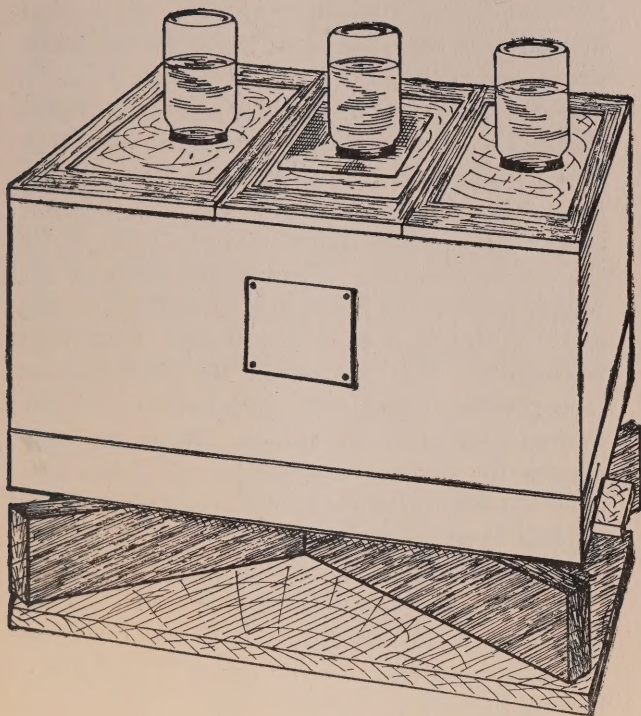


FIG. 7. Feeding three nuclei in one hive.

he should look for the queen-cell, the condition of which will tell him if the cell was torn down by the bees, or if the virgin emerged in the normal manner. If the queen-cells show normal emergence, and there are no eggs or larvae, it can be accepted, providing the weather has been suitable for mating, that disaster has overtaken the young queen. This will be confirmed or otherwise by the smaller number of bees in the queenless nucleus when excluder zinc is used at the bottom of the division boards. When such conditions are found, the division board can be withdrawn and an empty frame of comb substituted. Then feed both nuclei. This will prevent the production of laying workers and will not interfere with the normal routine of the apiary. When the time arrives for another distribution of queen-cells after the removal of the mated queens, the united nucleus must again be divided.

The queens must not be removed until their brood is capped, and in the case of tested queens, they must not be removed until some of their own brood has emerged, as the queen is tested for mating through the worker only.

Uniting Nuclei

To unite the nuclei in each hive at the end of the season, we prefer to remove all the queens,

and when the bees have discovered the absence of their queen to withdraw the division boards. This permits the thorough mixing of the bees in the endeavour to find their missing mother. If the bees are of a bad disposition, one of the queens is caged on a comb before the withdrawal of the division boards and released three days afterwards. With docile bees a queen, without caging, can be returned to the same hive from which she was taken, by inserting her in the hive on the same frame of brood and with the adhering bees that accompanied her. In all cases feeding when removing the division boards adds an element of certainty to the introduction and uniting.

Recording the Nuclei

The method of recording the internal condition of the nuclei hives is of the simplest. The usual system of using blocks of wood or stone in various positions on the roof to indicate conditions within is not conducive to quick work.

Every time the breeder wishes to manipulate, he is compelled to move the recording blocks. This entails a feat of memory worthy of a better purpose, and the difficulty of accurately remembering the original position of the blocks becomes greater as the number of nuclei examined

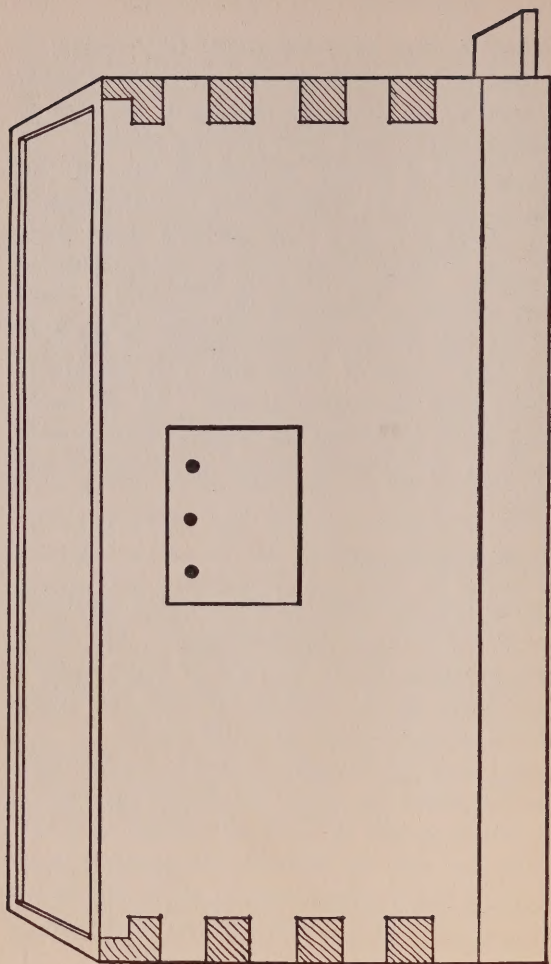


FIG. 8. Nucleus hive showing recording pins.

is increased, and the urgency of the work. Whatever is used in the way of indicators should not be on the roof, but in some position in which they can remain until the manipulation is completed. This entails no memory feat, the mind of the operator is free to be fixed on the work at hand, and when it is finished he is fully acquainted with what has been done and can arrange the indicators accordingly.

The author has devised a system to denote the interior conditions of the nuclei hives that meets all the above requirements. To the back of the hive is attached a small, thin piece of wood—about four inches by three inches, which has at both ends and between it and the hive-wall, a piece of doubled cardboard. Thus a space is left in the centre between the hive-wall and the piece of thin wood, and in this space is kept a small piece of loose cardboard on which is written such information as is found to be necessary. This piece of cardboard is doubled down its centre so as to make a crease and is then opened out and inserted in the space provided. By creasing the cardboard it requires no other fixing and is instantly available without the necessity of opening hives. As every group has indicators as will be presently explained, it is not necessary that each hive has the information on the cardboard. The

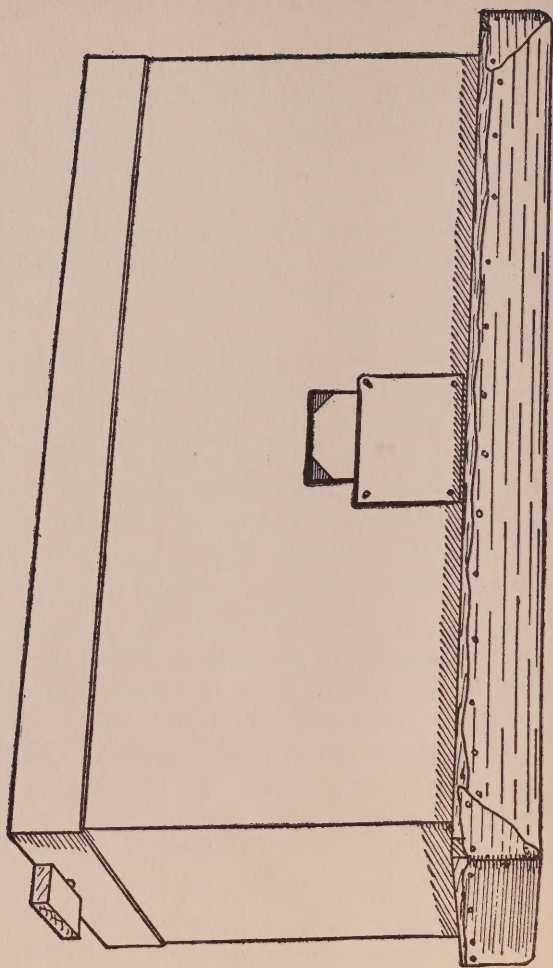


FIG. 9. Record card partly withdrawn to show how retained.

author's group system (see next chapter) does away with that necessity; only one such recording card is required for any one group.

With the piece of wood attached to the hive are used drawing pins to indicate the internal conditions of the hive. The pins not in actual use are fastened beneath the edge of the roof. The heads of the pins should be of large size, which facilitates their removal, and if the heads are coated with black enamel, the condition of the hive can be read at a considerable distance; the enamel also protects the pins against the weather and renders them much more durable.

It is not absolutely necessary that each hive has the recording pins. If the breeder will work on the group system, one hive with both card and pins will carry all the necessary information relating to the whole group. By using the pins at the top of the piece of wood, queen-cells or virgins are indicated; removed to the bottom, indicates mated queens—one pin being used to represent each nucleus—three pins to each hive.

For the purpose of recording the internal condition of a nucleus, we do not consider it necessary to make a distinction between a queen-cell and a virgin; therefore the two positions—one at the top and the other at the bottom of the pin-holder—are deemed to be sufficient.

CHAPTER VIII

THE GROUP SYSTEM

The Need for Such a System

In the work of a queen-rearing apiary, it is essential that when the time arrives for any particular operation, the breeder should be able to carry it out expeditiously and with certainty. This particularly applies to the work connected with nuclei, whether they are used for mating purposes in commercial queen-breeding, for the making of a strain, or for line-breeding.

The breeder should be in such a position that he can at any time remove queen-cells or queens of any particular breeding or mating without the necessity to refer to notes or records. This would require the possession of a system that is of itself almost automatic in its action, that eliminates the intricacies of the queen-breeding apiary, and that makes errors next to an impossibility. Such a system, termed the "Group System," will now be described.

What It Is

The "Group" system is one by which queen-cells or queens of a particular rearing or mating are dealt with collectively and not as individuals. The groups are made for certain phases of the rearing or breeding, and as those change, so the groups change also.

In the case of commercial queen-rearing each group consists of five nuclei hives, and each hive has provision for three nuclei, and therefore three queens. Thus each group carries fifteen queen-cells or queens—the number that is produced in each batch by the colonies kept for the purpose of queen-raising.

The hives comprising a group should be kept intact and separate from those of other groups. The best form in which to place them is a line, and if a stake is kept at the end of the group whose queens are next for removal to the reducing nuclei in the shed, there is no necessity to refer to any records or notes to find that group.

A great advantage of the group system is that where it is used in the mating of virgin queens, it tends to their even mating. By it the queen-cells inserted into the nuclei comprising a group are of about the same age and development, with the result that there is scarcely ever more than a day's difference in the mating of the queens in

one such group. This permits the removal of all queens of a complete group at one operation, and makes possible the distribution of all the cells raised at one setting of eggs to the hives comprising a group.

When a breeder commences to make his strain, or to prepare queens that will eventually form his strain, he will procure queens of several strains having the qualities nearest those he desires his strain to possess. As he progresses in his breeding by crossing and re-crossing, he will gradually accumulate such a collection of those crosses as to make a proper selection therefrom almost an impossibility. He will find it necessary to take many notes, but if he does that thoroughly, he will soon discover that he has undertaken a formidable task. Therefore he should avoid if possible attempting to keep records of individual queens. Sooner or later confusion must result, unless he is prepared to do an enormous amount of note-taking, with the probability of being deviated from his original intentions. And it is fundamental that he never should lose control of his matings.

When making a strain the groups are bred and retained for a certain phase of the breeding, and when queens from them have fulfilled their purpose, they are removed from the apiary. By this

means the apiary is kept clear of unwanted, because used, queens; space is provided for the younger stock and the breeder's thoughts are not diverted to useless details.

However many crosses are made in the making of a strain, there can never be more than four groups with a possibility of four matings. And this permits of two kinds of drones being flown each year; but since neither all the groups nor the matings are made use of in any single season, the working of the groups is more simple than it appears to be.

The Purposes of Various Groups

Groups are raised for the purpose of either (1) providing queens only; (2) providing drones only; (3) providing both queens and drones where it is intended to inbreed to fix a valuable characteristic; or (4) providing drones and queens for use other than inbreeding.

Advantages of the Group System

While the advantages of the group system as applied to the making of a strain are many, in actual line-breeding operations the advantages are still greater. Even where the breeder's apiary does not reach the hundred stocks, there is a perpetual difficulty in selecting with any degree

of accuracy the best queens for breeding purposes. In fact, under the usual conditions of breeding, it is impossible to find the best queen. They are reared at different times and under entirely different conditions. They are put into stocks that vary in many particulars, and the following season these same queens, although they all started off a different mark, are judged by the same standard! It is by such methods that the best queens are missed and their rightful places frequently taken by those of inferior quality.

In using the group system, all those difficulties are overcome. All the queens comprising a group are raised in the same hive, by the same bees at the same time, and under identical conditions; and finally they are tested among themselves and in competition with no other queens. And the breeder need never go outside a group to find with accuracy his best queens, that he will find in no other way. By the group system the breeder's work is systematised; is always in a direct line and actually prevents any errors in breeding, selecting, and mating; and because of its simplicity and definiteness, it reduces the work of both head and hands.

Group Cards and Their Markings

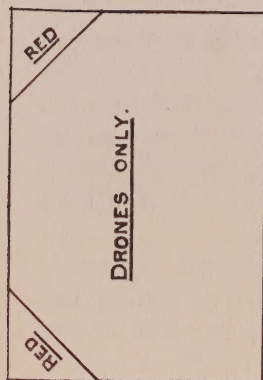
The breeder should supply himself with cards

which can be so marked as to place at his disposal records that will be accurate; that will save much mental exertion; and that will be immediately understood without reference to notes.

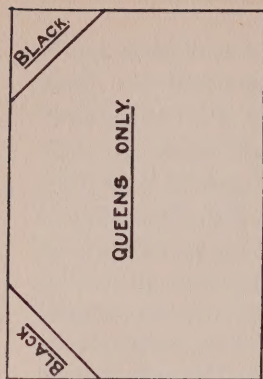
The group cards are marked in four ways with two colours—black and red. For those groups providing drones only, the two upper corners are marked in red: for those groups providing queens only, the two upper corners are marked in black; for the group providing both queens and drones, one corner is marked in red and the other in black. With this last group that marking denotes that the queens and drones can be used to mate with any other drones and queens respectively. The fourth group is to be used for inbreeding purposes only, and the four corners are marked in red.

There is no necessity to have a card for each queen. If the apiary is arranged in such a way that the end hive of a group is nearest the line of approach of the apiarist, one card for each group is sufficient.

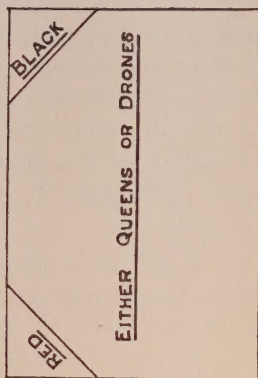
As a single-purpose group—one for either queen or drone raising—is used in the matings and then finished with, a cross is made on the face of the card for that group, and as soon as queen-cells or young queens are available, and if the room of the used group is required, the cards



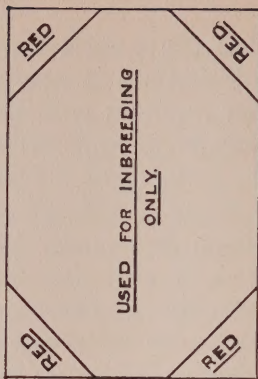
1



2



3



4

FIG. 10. Recording cards.

and the queens are removed. In the case of a double-purpose group, where drones will be required at one time and queens at another, a line is drawn diagonally across the card from the colour representing the caste that had been used; *i.e.*, in the case of such a group giving queens a line would be drawn from the black corner to its opposite diagonal corner.

The Group Numbers

In addition to the coloured cards each group is given a number, and the numbers of the groups from which a group came is placed as a fraction behind the group number; that of the group supplying the drone being made the numerator, and that of the group giving the queen as the denominator. Thus a new group is made whose number is 15. This group came from a combination of drones from No. 13 group and from queens of No. 12 group. Therefore this group would be represented by a symbol like a mixed number, $15\frac{1}{2}$, which is sufficient to establish the parentage at any time.

We should like to call special attention to the value of the fraction-symbol after the group number. The system of breeding herein described is taken through the drone and not the queen, and it becomes imperative that both the

qualities of the drones and their line of descent is known. The fraction-symbol quickly provides knowledge of the latter and the workers themselves knowledge of the former. For instance, when we observe and test the workers of the group $15\frac{1}{2}$ we become possessed of the knowledge of their value for breeding. If those qualities are good and considered suitable for retention, we have only to refer to the groups whose numbers comprise the fraction-symbol to see the line of descent and judge whether to include those characteristics through the drones or not. If it is decided to so include the characters of these workers, we raise reproductive sisters to them, mate them to other selected drones that have undergone a similar test, and the following year fly drones from young queens. The drones so flown are fully representative of the workers of the group $15\frac{1}{2}$ and by flying these drones, we incorporate all their characteristics in our strain; truly a system of progressive breeding.

CHAPTER IX

MARKING AND CLIPPING QUEENS: CAGING QUEEN AND ESCORT, ETC.

Marking Queens of the Black Races

With the majority of apiarists who mark their queens, very seldom is anything done other than to clip the queen's wings. This, however, is not entirely satisfactory, since the queens so marked can be identified for the first and second years only: assuming, of course, that the queen's wings are clipped alternately—one year, the wings on one side are clipped; the next year those on the other side. With the black races of the bee, something more than the mere clipping of the wings is required. It is not an easy matter to find a black queen in a fairly strong stock. She should, therefore, be marked with a colour that immediately strikes the eye when the comb of brood on which she is parading is withdrawn from the hive and exposed to view.

The Method of Marking Employed by Swiss Breeders

The Swiss breeders use a paint for marking queens consisting of an alcoholic varnish with which is rubbed up quickly enough powdered pigment to form a fairly thick paste. To this is added quickly enough ether to make it thin and runny. The container must be well corked as the ether being very volatile will quickly evaporate. The pigments that have been used in the author's apiary to mix with the alcoholic varnish are "permanent red" and "middle chrome yellow," both in dry powder form. With regard to the varnish a word of caution is necessary. In such an operation as painting a queen it is obvious that whatever paint is used, it must be of a very quick drying nature. It is for that reason that ether and alcohol are used, as both evaporate very rapidly and leave the pigment and gum hard and firmly fixed to the queen. Therefore any kind of varnish will not do—it must be alcoholic. There are many varnishes that consist of nothing but oil and resin, which are united when in a heated condition. These are useless for the purpose of marking queens, because of the length of time required for drying.

The Swiss method of applying the paint to the queen is carried out in the following manner: ob-

tain a pill-box and from it remove the top and bottom. This will leave two rings of cardboard, one fitting inside the other. Between the two rings fix a piece of large mesh net, such as is used in the making of ladies' veils. Place this implement over the queen to hold her still while the paint is being applied. Apply the paint with a small brush and immediately lift the net so as not to smear her with the paint. She should be covered with a tumbler or something of that sort for a few minutes to let the paint dry before she is permitted to rejoin her stock or nucleus. She can then be allowed to run among the bees.

While this method is effective, it is thought to be too troublesome for the many. Simplicity is the great need in all things pertaining to bee-keeping operations, and especially to those connected with breeding. In this matter of marking queens we believe that apiculture in this country, in neglecting to mark queens effectively, is losing one of the best means of securing choice queens—those bred by supersedure. Then again, how many apiarists are there who can tell with absolute accuracy the age of any queen in their apiaries? And if we cannot tell the age of our queens, how are we to discover those showing the possession of that most desirable characteristic—longevity?

Much time has been given and many experiments made with the object of finding a method of marking queens that shall be of the simplest nature; and a paint that shall dispense with the mixing by the breeder. Such a method and paint are now described.

The Author's System of Marking Queens

The paint finally selected by the author is a golden one, manufactured by T. Pavitt & Sons, and named "Ardenbrite." This paint is put up in flat tins having a wide opening. This is an advantage as the possibility of upsetting the tin is more remote than would be in the case of a bottle; and the large opening facilitates the application of the paint. Since, however, we believe it to be necessary that the age of any queen should be determined from her marking for four years, we use another paint alternately with the golden one just mentioned. This second paint is made by the same firm, and goes under the same name, but is an aluminium paint.

These two paints are used in conjunction with clipping the queen's wings. The golden paint is used for two years and the queen's wings are clipped alternately—one year, the wings on one side, the next year, the wings on the other. The

aluminium paint is used and the queen's wings clipped in a similar manner during the next two years. Thus the markings extend over a period of four years—long enough to determine the age of any queen.

To save time and labour and the frequent manipulation of nuclei, both the painting and marking should be done in one operation. In that case a method of holding the queen different from that usually employed was found to be necessary. The usual method of holding a queen is with her thorax between the thumb and forefinger. But in this position, which is suitable for clipping only, the painting could not be done, because the paint is applied to the upper surface of the thorax which is covered by the thumb. That was overcome, but we shall describe the whole routine from the beginning.

The paint and brush with which to mark the queens, together with a pair of scissors with which to clip the wings, are arranged on a table near the window in the shed containing the nuclei. If the reader's conditions are different from those now being described, it is suggested that the frame of brood on which the queen to be marked is found, be quickly carried in an uncovered box to a warm room. Most of the old

bees will fly from the box before reaching the room, and so the apiarist will be caused less annoyance from such.

How to Hold the Queen When Marking and Clipping

The queen is gently taken up in the usual manner by the wings between the thumb and forefinger of the right hand. She is then laid on the first joint of the forefinger of the left hand, with her legs on either side, and with her head towards the root of the finger. The thumb of the left hand is then closed on the finger with the legs of the queen between them. It is most essential to have at least two of the three legs of the queen between the thumb and finger, for if only one is held, the queen may injure herself by endeavouring to turn round. When the queen is first placed in that position, she will use her wings in an endeavour to release herself, but finding it useless soon desists. As soon as the queen is secure, the brush is dipped into the paint and then applied to the upper surface of the queen's thorax. The brush is then placed on the table, the scissors picked up and the wings are clipped according to the year of birth and the system employed. By this time the paint is dry enough to permit the queen being released among the bees.

When clipping the right wing of the queen, it is necessary to close the second finger on the first with the legs of the queen between them. In clipping either wing it is essential that the posterior legs be held as those are the legs most usually snapped off when clipping.

Caging Queen and Escort

The usual method of caging queens and workers is by placing them singly in an opening in one end of the cage. The cage is held in the left hand with the opening downwards, in such a position that the thumb can cover the opening between the insertion of any two bees.

The worker is picked up by placing the thumb and forefinger of the right hand near the wing roots, and gradually closing and sliding them backwards and upwards with the wings between them. The head of the bee is then inserted in the opening and the bee will readily crawl into the cage. When sufficient workers have been caged the queen is caught and caged in like manner. About fifteen bees to act as escort to the queen is sufficient for travelling in this country. It is not advisable to include very young bees in the escort.

Although queens will live a long time in a cage, they should be confined for as short a time

as possible. Previous to their despatch, the purchaser should be notified of the probable date of their arrival. This latter cannot be fixed with absolute certainty owing to the possibility of weather conditions interfering with caging operations. This is greatly overcome by the retention of nuclei in sheds.

The foregoing method of caging queens has long been the only one used. But moving with the time and new equipment, it becomes necessary to employ a more expeditious method. Up to the present, however, no cage has been designed that will permit the insertion of the bees in any other manner. But the author's new cage alters this. The necessary number of bees to escort the queen can be inserted in the cage at one operation. This is done by the use of a small funnel, which fits on the end of the cage having the wide opening. The mouth of the funnel is held beneath the comb of brood and bees on which the queen to be caged is carried. The comb is held in a slanting position over the funnel and the bees are gently brushed with a large feather into the funnel from which they fall into the cage. The queen is picked up in the usual way and gently dropped on to the bees in the cage. The cage is gently jarred to dislodge the bees from the side of the cage, the

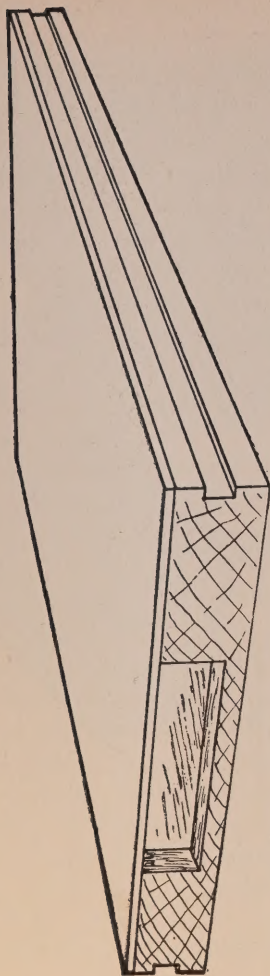


FIG. 11. Travelling and introducing cage showing large opening when covered.



FIG. 12. Small funnel attached to queen cage for inserting the escort.

funnel removed and the opening at once closed with the piece of brown paper. The perforated paper is then put in place and secured by the gum on its ends to the cage.

Making Candy

The making of candy for queen-cages calls for much care. It is required to remain soft for some considerable time, so that the confined bees are able to consume it, and to save the apiarist the need of frequently making a fresh supply.

There are a good many recipes for making candy that contain as ingredients both glucose and cream of tartar. As the function of these is similar, being, in trade terms, to kill the sugar, there is no necessity to use both, and as the tartar is more easily procured, we advise the use of that in preference to the glucose.

Either an enamelled or aluminium saucepan is a suitable vessel in which to make the candy. Into the vessel put ten pounds of crystallised cane sugar, one quart of water, and one half teaspoonful of cream of tartar. Stir the contents until the sugar is thoroughly melted, then gradually bring to the boil, stirring the whole time, until all the sugar is thoroughly dissolved. The stirring should cease before the sugar boils. During the boiling, the sugar is inclined to creep up

the sides of the vessel. This sugar should be wiped off by using a wet brush. If the creeping is allowed to continue, the candy will be coarse in grain.

We strongly advise the use of a sugar boiling thermometer in candy making, as being more exact, and we know of none that is so suitable for the purpose as that offered by *The British Bee Journal*. If using a thermometer of another make, the temperature should be allowed to reach 238 degrees. At that temperature the vessel can be removed from the fire and placed in another vessel containing cold water, and a few drops of cold water sprinkled on top of the syrup. This prevents a skin forming, which is also inclined to cause the candy to be rough in grain. When the syrup has cooled sufficiently to allow a finger to be kept in it for half a minute without any unpleasant sensation, it can be stirred. The best tool to use for the stirring is a butter-pat. Stirring should continue until the syrup turns from water white to milk white, when it becomes of the consistency of paste and then stiff. Before it becomes quite stiff, put it into another vessel in which has been previously put one teaspoonful of water. Put this second vessel on the fire and stir the candy, which will become liquid, until all the lumps are removed.

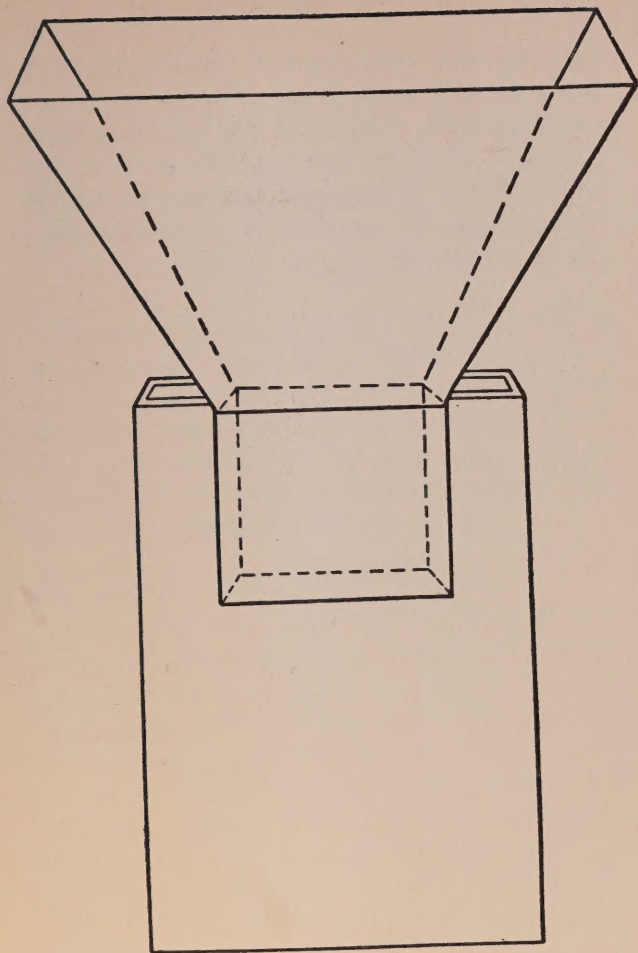


FIG. 13 Method of inserting the escort into the queen cage.

Then add one teaspoonful of glycerine to every ten pounds of sugar used. The glycerine prevents the candy drying out and becoming hard. Glycerine candy we do not recommend for winter use. When the glycerine has been thoroughly incorporated, the cages can be given their quantity of candy.

CHAPTER X

QUEEN INTRODUCTION

It has been estimated that fifty per cent of queens introduced to alien stocks are lost annually. While that estimate is a probable exaggeration, it is certain that the number lost is large, and although the bee-keeper has paid for his new queen, she is of no actual value to him until she is safely introduced.

The Cause of Bees Refusing a Queen

Bees may refuse a queen because of a peculiarity in their disposition; because of another queen or queen-cells in the hive unknown to the bee-keeper; or because the stock while queenless contains laying workers. Introduction to stocks is impossible while laying workers remain. And although it is the usual practice to break those stocks up, it is not necessary to do so, since the method given herein will overcome that difficulty, providing the stock is not much reduced in numbers.

Usual Methods of Introduction

The usual method of introduction is to remove the old queen, if she is still in the hive, and to place the new queen in the cage in which she travelled, on the top bars of the frames in such a position that the wire screen is downwards, and between two frames. The bees are allowed access to the candy in the cage through a small hole; they consume the candy and in so doing, make an exit for the queen. The queen may also be inserted by the cage being placed on the face of one of the combs, but in this case there is either an addition to the travelling cage, or else the new queen is removed entirely from the travelling cage to another of a different pattern, which permits it to be pressed into the comb. These methods, in addition to some uncertainty, have some objectionable features, such as length of time before the queen is released and commences to lay, and the number of visits and manipulations necessary.

Theories Governing Introduction

The accepted theory that governs introduction is that the new queen will not be accepted until she has acquired the odour of the colony, which she is intended to head. This theory the author rejects. It does not explain the per-

sistent refusal of some stock to accept a new queen, although she may have been caged in the hive long enough to make it certain that the colony odour had been imparted to her. On the other hand, some colonies will accept a new queen before there is any possibility of her having acquired the odour of her prospective family. The starvation method and the ready acceptance of strange queens by queenless and broodless bees are cases in point.

Methods Employed to Influence the Queen or Stock

Methods of introduction are directed to promote an abnormal condition in either the new queen or in the stock to which the introduction is to be made. In the former case there are practices, such as dipping the queen into water, or into honey; or by starving her. Where the stock is thrown into an abnormal condition, such methods as heavy smoking after the removal of the old queen are resorted to, or the stock is deprived of both queen and brood. The methods applied to the queen are not satisfactory. Dipping into water, unless it has been previously warmed, endangers the queen to a chill: in dipping her into honey, owing to its viscid nature, there is the possibility of blocking her breathing organs,

and starvation is not ideal for such a delicate creature as a queen. And since there is a method that has none of these objectionable features, there is no need to use them.

The Question of Disposition

It can be taken as an axiom that bees will not accept a new queen unless they want her. Some want a new queen much sooner and more intensely than others. And that being so, it is primarily a question of disposition that influences the ready and willing acceptance of another queen. The greater the want, the quicker the acceptance. Therefore, it devolves upon us to find, if possible, a means that shall create that want in an intensified form. It is frequently affirmed that it is the older bees that raise objections to the new mother. If that is so, and it probably is, then it is this attitude on the part of the old bees that must be changed into an anxious willingness to welcome another head to the family. We can achieve that result by removing both the old queen and all the brood. Without the means of raising another queen, the bees quickly realise their utter helplessness, and when the bee is thus deprived, it becomes the most abject of creatures, and what objections it previously had have now departed; anxiety and

despair have taken possession, and where unreason may have actuated it in its refusal, it will now readily accept without question any queen that will function as a mother.

The removal of the brood, however, entails a considerable amount of trouble and a like amount when returning it. But the method is sure and where one has paid half a guinea for the new queen, it is worth a little more trouble to resort to that method. When the brood is removed it is fundamental that the queen be not only given quickly, but that the cage in which she is inserted be such as will assist in her rapid release. The author realising the troublesome task of removing all the brood, has devised a method and cage that eliminates the necessity to remove all the brood; that enables the old queen to be retained while the introduction is taking place; that uses the cage in which the queen travelled and without any addition thereto; that calls for no equipment beyond what an apiary should normally possess; that is swift in operation (the author has had queens laying six hours after insertion); and finally, that is absolutely certain.

The apiarists of America have long desired a method of autumn introduction that is sure and quick, and that shall reduce the loss of brood to

a minimum. The method herein advocated, not only fulfills all those conditions, but actually by the retention of the old queen, increases the amount of brood. A man could, provided he had the queens on hand, and the necessary division boards, safely introduce a hundred queens within the period of a day's work, and have all the queens laying by the following day.

The Author's System of Introduction

In explaining the author's method of introduction, the preparation of the hive will be described first. The hive that more readily lends itself to the method to be given, is one that has the frames parallel with the entrance, although there is not a great difference between the two kinds. Whatever hive the apiarist has he must prepare it so that it comprises two *absolutely* bee-tight compartments. This is fundamental. Three frames are removed from the hive. Usually the two outside frames do not contain brood, but if they do, those and the third frame must be given to a stock whose brood-nest is of such a size as to take them. The compartment to take the new queen need only be of a size to take three frames, although only two frames are used therein. Each compartment must be provided with an entrance—the smaller, which is to re-

ceive the new queen, has its entrance to the original front; the other compartment has its entrance to the rear. It is unnecessary to go into further and more minute details; each can arrange his hive according to its particular pattern, and the principles stated above. Special attention should be given to the space under the lugs of the division boards. These must be blocked, otherwise the bees will be able to pass from one compartment to another, which would upset the whole arrangement. Each compartment should be covered separately so that the bees in each can be manipulated without interfering with its neighbour. The two frames used in the small compartment should on no account contain brood or eggs, and to prevent the possibility of such being introduced, the two frames should not be taken direct from the hive, but from those that have been out of the hive several days at least. Of the two frames, one should contain several pounds of honey; the other should be empty. The comb containing the honey should go next the hive-side. If pollen is available to the field bees none need be given in the comb, as the gathering of pollen is a sure indication that things are right inside. The division board, which must make the two apartments bee-tight, is placed against the frames remaining in the hive.

The two frames are placed in the smaller compartment at such a distance from the board as will permit the cage with the queen to be inserted between the board and the near frame. The hive is left in that position for about half to one hour, according to whether the bees are flying freely or not.

During that period the field bees will fly from the rear entrance and return to that in front. Finding no queen or brood there, they are put into the best of tempers to receive a new queen. When the apiarist is satisfied that the greater number of old bees are in the field he can quickly and easily find the queen in that division containing the old nest. When found, she is put on one side, and two frames of the youngest brood have their adhering bees quickly shaken in front of the entrance to that part having the two frames. The frames of brood and the queen, if she has been entirely removed, are replaced and the hive closed except the entrance. The hive is now in a condition to receive the caged queen.

The Author's Queen Cage

The cage is of the ordinary pattern, except that it contains six holes instead of three. It has no wire screen, a cover of wood being used instead. If the queen had to be sent by post on a

longer journey than she has to take in this country, it might be necessary to cover the cage with celluloid, through which the condition of the queen may be seen; but as the postal journey is short, there is scarcely any danger of the queen arriving dead. One of the end holes in the cage contains candy. At the opposite end, the centre piece between the two end holes is removed to within half an inch of each side. This is to facilitate the insertion of the queen and her escort, and also to provide an easy exit from the cage into the hive. When the queen and her escort are placed in the cage, a piece of rather stiff but rough brown paper is placed over the end. This piece of paper is about 2" by 1", has one edge flush with one side of the cage, and is then bent so that the portion not actually covering the end lies on the opposite side of the cage. This portion is taken between the thumb and fingers when preparing the cage for the hive, and the piece of brown paper is gently pulled from between the wood and another piece of paper that is fastened to the cage and is not removed. This last-mentioned piece of paper is of much lighter quality than the brown, and has small perforations along its centre, which permit the bees to feed the inmates of the cage and give them a start to tear the paper away and so release the

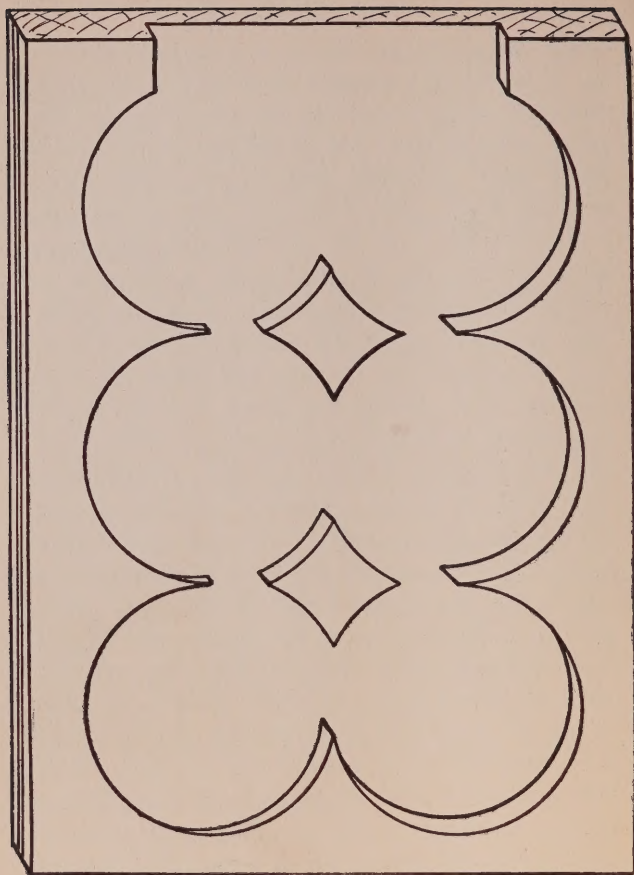


FIG. 14. A six-hole travelling queen cage, showing the middle portion at one end cut away to form a wide exit for the queen. This end is covered with paper which is torn away by the bees and the queen released. 176

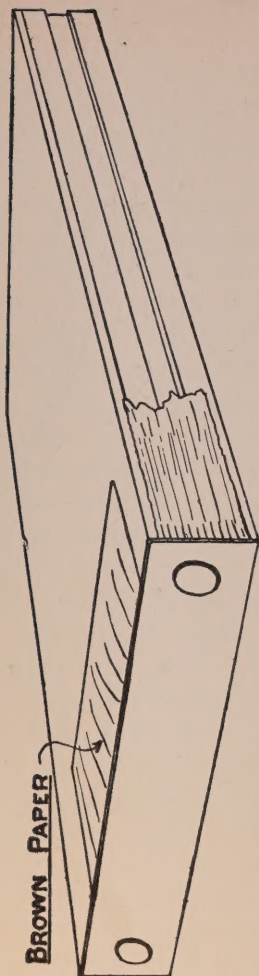


FIG. 15. Travelling and introducing cage with brown paper in position and the perforated paper covered with a piece of cardboard secured with two drawing pins: ready to travel through the post.

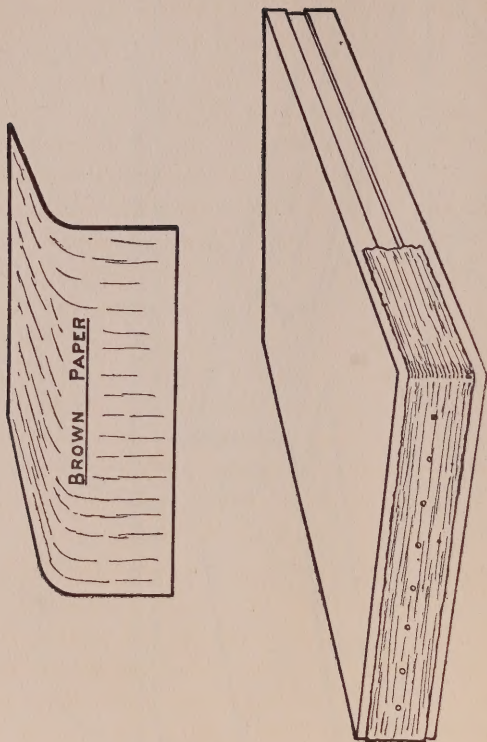


FIG. 16. Travelling and introducing cage with the entrance covered with perforated paper. The piece of brown paper has been withdrawn from between the perforated paper and the cage: its function is to protect the perforated paper from the bees while travelling.

queen. The ends of the perforated paper are gummed and fastened to the edges of the cage immediately over the brown paper; but great care must be taken that the two papers are not fastened together; for one piece, the brown, has to be removed before the cage is inserted into the hive, and the other, the perforated piece, is not removed. The brown paper is used as a shield to the lighter and perforated paper, until the hive is fully prepared for the reception of the cage. For travelling purposes the end holding the paper has a piece of stout cardboard fixed as a protection to the paper. This cardboard has to be removed similarly to the brown paper in such a manner as not to break or tear the perforated paper beneath it. To facilitate its removal it is attached to the cage by two large flat-headed tacks, which should be extracted by inserting the blade of a knife beneath their heads. If the knife is inserted beneath the cardboard, it is certain that the paper beneath will be broken.

When the apiarist is satisfied that the conditions of the broodless compartment are right, he removes the cardboard and then turns a piece of bent wire, at the opposite end of the cage to that holding the paper, to right angles to one side of the cage. This piece of wire is laid over the top of the division board, supports the cage thereon,

and allows both the cage and board to be withdrawn simultaneously when the introduction has been accomplished. He then gently withdraws the piece of brown paper. In this operation care must be exercised when removing the brown paper that the other piece is not broken in any way, for if that were to occur, the bees and queen in the cage would be at once released. The cage is not prepared as described above, until the very moment comes for its insertion into the queenless and broodless portion of the hive. The young bees shaken from the two frames of brood will act as nurses and begin to feed the queen through the holes in the paper, which will eventually be broken down by the bees and the queen released.

When the apiarist wishes to unite the two parts, which should not be too long delayed, he can remove the old queen, and when the old portion of the stock has discovered her absence, withdraw the division board with the cage, and in its place insert an empty comb, except that it contains a little food. If from twenty-four to thirty-six hours are allowed to elapse between the insertion of the new queen and the removal of the old, the former will be found to be laying, and being accepted by the old bees is safe from the young ones. The frame of comb that takes the place of the division board acts as a temporary division

board, gives the young queen room in which to lay and the food it contains makes towards a contented condition of the stock.

This system of introduction is very simple. All that is really required is a division board and the necessary blocks of wood to make the hive into two bee-tight compartments.

CHAPTER XI

THE BREEDING INFLUENCES OF THE MALE

The British Stock Breeder

It is somewhat strange that with all the natural aptitude possessed by the British stock-breeder—with his proved ability to breed the finest stock in the world—with one of the most suitable climates for the purpose—he should be behind the breeders of another country in the breeding of one particular stock—the dairy cow. Bullocks for beef, sheep for mutton, pigs for pork, as bred by him, are the best to be had and they and their fame have spread throughout the civilized world. Although these animals excel in qualities that are judged by eye and hand, it is much the same with other stock, whether its breeding has been based on performance, as in the case of the race-horse, or on production as in the case of poultry. With one stock, however, the British breeder is behind, and it will repay us to search for the reason.

Cattle Breeding in Denmark

When Denmark began about half a century ago to record the quantity and quality of milk from her dairy herds, her dairying position was no better than that of Britain. But with those records it was possible to discover where improvements had been effected and to trace such improvements to their responsible source. In the same country about the beginning of the present century, it was observed that in the Red Danish breed of dairy cattle daughters of certain sires were such an improvement upon their dams that the sires came to be known as "butter bulls." Some breeders were quick to take advantage of this discovery and incorporated the blood of these bulls with their own dairy herds. The most happy and profitable results followed, the rise in the quality of the milk being progressive in almost every case, with the consequence that the Danish dairy herds in productive capacity outstripped those in this country. Later on, some valuable information was forthcoming from Denmark which indicated that there were three grades of cows giving in round numbers, 500, 750 and 1,000 gallons of milk during a normal lactation period. The bearing that this information has on the present discussion will be seen

later, but because of its importance, the reader is requested to keep the point in mind.

Beyond the Danish discovery of those special bulls there was no apparent reason for the difference between the dairy herds of the two nations.

The possibility of possessing such bulls could not be with one nation only. The Danish breeders possessed no abilities superior to those of British breeders. The Danish climate and country were in no way superior to those of Britain. Where then was to be found the cause of the difference between the two countries? A patient investigation eventually revealed that cause.

The Capacity of the Sire

A sire's breeding capacity can only be determined through his reproductive daughters. In the case of the milch cow, such daughters would come into profit when about three years of age. Their sire at that time would be about five years of age. In Denmark it is the practice to retain promising sires until after their daughters have been tested. In Britain the very reverse takes place. Few indeed are the sires in this country that have not been butchered or exported before they reach the age at which alone could their

value as breeders be determined. Here then is the real cause of Britain's inferiority, which can be attributed to nothing else than the premature disposal of the males, thus causing her breeders to rely solely on the female to transmit her characteristics to the daughters.

In breeding, every mating, unless the male has been tested through his daughters, is purely speculative, and in some instances, may even be disastrous. Breeding to be progressive demands that strength be mated to strength. But such mating is impossible of accomplishment, unless the characters of both male and female are known. To rely solely on one sex is not the very best of practice, although much is to be gained by careful attention to and reliance on the male. To rely solely on the female is the very worst of practices and nothing but disappointment has followed such methods.

Experiments in Poultry Breeding

The Danish discovery of the inability of the cow to transmit her qualities to her daughters, would have been, by itself, far less convincing had it not been supported in an unsuspected direction, and with another kind of domestic stock. During the period of 1898 to 1908—ten years—at the Agricultural Experimental station at Orono,

Maine, U.S.A., an attempt was made to improve the laying capacity of its Barred Rock breed of poultry. Work was based on the theory that such improvement could be made by breeding from the best females and their progeny, but at the end of ten years no progress had been made and it became clear that no improvement could be achieved through the female. That is not to say that the female is valueless. All history and all breeding experience prove that the hen can and does carry her qualities in a progressive form. The bird from which our domestic poultry originated laid no winter eggs and comparatively few in summer. Yet we now have hens capable of laying annually well above the three hundred mark. What is advanced here and confirmed by evidence from many quarters, is that the female cannot transmit those qualities she is known to possess to her daughters; and therefore reliance on her female progeny for a continuation of her characteristics must be looked upon as being unsound.

The Grades of Stock

Such was the position at Orono when Dr. Pearl took charge, and he eventually found that hens, regarding their laying capacity, fell into three grades as did the Danish cows. Within a

certain fixed period in its first winter, the best grade gave over thirty eggs; the next best under thirty eggs; and the worst no eggs at all. Practically the same discovery was made almost simultaneously by Miss Murphy of the Munster Institute, Cork.

Although both Pearl and Murphy discovered a method that indicated the class to which the fowl belonged, the problem of transmission was a discovery of a later period. Before mentioning the results of various matings, it would be as well to state how the three grades of fowls are designated. The best class is now termed L2; the next best L1, and the worst, zero. Hitherto, the evidence that the female cannot transmit her qualities to her daughters has been on the negative side. Now we come to evidence that is both positive and negative and evidence that is decisive. If a hen carrying the L2 factor—a really good layer—is mated to a proved L1 male, all the female progeny will be bad layers. Reverse the matings, however, by putting an L2 male to an L1 female, and half the pullets therefrom will be good layers and the other half poor layers. But although an L2 male mated to an L2 hen will produce all L2 daughters (strength to strength) it is not so with the sons—they are of both classes, L2 and L1, and the only way to find out

which is which, is by actually mating them and testing their female progeny. When it is known that a cock mated to an L2 hen produces all L2 females that cock is an L2 bird, and should be retained until he or the owner dies.

We have introduced examples of the breeding of other stock to demonstrate the fundamental importance of the male, to enable the reader to understand the principles of breeding, and to prepare him for the theories, based upon experience in breeding other varieties of live-stock besides the bee, that the author advances further on.

The Position of Present-Day Bee-Breeding

The present methods of bee-breeding are similar to those prevailing among breeders of dairy cattle, although in cattle breeding there is evidence of a change taking place. The queen, like the cow, is considered capable of transmitting her characteristics to her daughters, who in their turn are expected to pass on their qualities in a similar manner. This, however, has already been shown to be contrary to breeding laws. The female, more than ever, is coming to be looked upon as a receptacle into which characteristics from the male are deposited to become either peacefully united or perpetually at war with

other characteristics belonging to herself; the combination, of whatever nature, being reproduced in her offspring, and passed on to the succeeding generation through the male. And the task confronting the breeder is to eliminate any undesirable characteristics and the intensification of their opposites, so that those qualities only that tend to increase the economic value of the stock shall form a part of the constitution of the males, who alone are capable of transmitting qualities.

Those qualities that are fundamental in the bee are exhibited in the workers only. The reader may be surprised that the quality of fecundity is ignored; it is purposely ignored, as its possession is of minor importance. It is through the worker that knowledge of the value of a stock is obtained. By testing the queen's worker-progeny, we ascertain their value, but their characteristics cannot be ascribed exclusively to the queen. Her workers are representative of only half her blood, the other half being that of the drone with which she mated. Therefore the qualities possessed by the workers must be attributed to the combined influence of both parents.

Because the workers are sterile it has been taught that the only way to propagate their desired characteristics was to do so through their

reproductive sisters, the queens. But that teaching is wrong, since it is impossible to carry the characters of a queen to her mated daughters, because the act of mating adds other influences, frequently, if not invariably, greater than those of the mother queen. If, further, I mate a virgin raised from the best queen whose qualities I wish to fix, it is certain that the drone with which she mates will be from a queen inferior in the desired qualities to the queen mother. Therefore, by that method of mating I at once lose half the blood of my virgin; and I further make possible, and most probable, the entry of an unknown quality that may cause a reversion in the young queen's progeny, and so cause me to lose again the qualities the old queen possessed. And every time a similar selection and mating takes place, the same loss arises, since the better the selected queen mother, the greater the probabilities of losing her value through the mating of her daughters. Even where the quality of the drone is known the practice of using the best queen as a queen mother establishes the fact that such breeding is on other than progressive lines. The proper description of such methods of breeding and mating is "dispersive," since it tends to scatter qualities that are desirable and worthy of retention.

While there is a similarity in the methods of breeding the dairy cow and the bee, the reason for one method is different from that of the other. Present-day bee-breeding methods, apart from the food question, are primarily due to the misunderstood position of the drone. Were the method of fertilisation in the bee different from what it is—were it similar to that of other domestic stock—we should probably look with different eyes on the breeding and mating of our bees. Because, through mating, the drone disappears, we are apt to forget that his influence is still with us; that a drone, for mating and through mating, does not die, but simply becomes incorporated with the queen, and the length of his life for breeding purposes may be computed as being the same as that of the queen. By this non-recognition of the position of the drone, we have lost sight of the fact that every fertile queen constitutes in reality a *breeding pair of individuals*, since she has the essential part of the drone within her.

Previously it was said that all fundamental characteristics are exhibited in the worker. Since she is sterile however, we are confronted with the problem how to impart those characteristics to future progeny. Let us carefully examine this matter. Some stocks are being tested for worker

qualities such as energy, surplus gathering and docility, and one stock stands out conspicuously as possessing those qualities. As already suggested, if queens are raised from the queen heading such a stock, we shall probably lose the desirable characters as exhibited by the workers. How then, are we to breed so as to incorporate those qualities in the strain? We cannot fly drones from the queen since they are not representative of the workers, being one generation further back and having only one-half the blood of the workers under test. To fly drones from that queen would be no better than to raise queens from her.

Probable Mendelian Ratio of the Grades

We can with advantage now return to the principles that have been discovered in the breeding of other varieties of live-stock. It will be remembered that we drew attention to there being three classes both in dairy cattle and poultry; and there is no reason to believe the contrary in the case of the bee. In fact, the author is fully convinced that these classes do apply to the bee: which explains why some stocks never seem to progress until the queen is superseded. But the point here is to do with the drones. Under present-day methods of mating, drones from all

classes of queens will be flying. Assuming the accuracy of the application of the three classes to the bee, it is most probable that they are in the Mendelian ratio of 25, 50 and 25 per cent. In the ordinary way of mating therefore, the chances of a virgin queen mating with a drone equal in quality to an L2 cock is three to one against! What becomes, in those circumstances, of the superior qualities that were discovered in the worker, and which were the cause of queens being raised from that particular mother? They are scattered to the four winds of heaven and most probably lost for ever to the apiarist. When the queens are finally mated, the progeny of the seventy-five per cent of queens mated respectively to drones the equivalent of the L1 and zero poultry males, must also belong to the two lower classes.

Variation in the Amount of Surplus Honey—the Comparative Responsibility of the Queen and the Drone

In the foregoing we have an explanation of the great variation in the amount of surplus honey among colonies headed by queens of the same age and breeding, and receiving similar treatment. This variation has long been a puzzle to many. Theories of different values, some

reasonable, some grotesque, have been advanced to explain this variation, but the present writer has never yet come across one that even approaches what he believes to be the real cause. Where nectar is available for all colonies alike, the difference in performance is usually attributed to the queen. But we should not make the mistake of blaming her. She is by no means fully responsible for the condition of her progeny; in fact, her responsibility is far less than that of her drone. Shall we then blame the drone? Why not? He is said to be an individual of no character; to be bibulous, lazy and only on pleasure bent. But since he is a necessary person it might be advantageous to consider both him and his position a little more closely than has hitherto been the practice. The drone and his true position in breeding has been obscured by the elevation into the lime-light of that royal personage—the queen. Why her consort, if not king, should have been relegated to the inferior position in which he has been placed, is difficult to understand. Have we in instituting a female monarchy in the same act instituted a court of injustice? Has the drone no other useful function than to be the prospective father of a host of unsexed daughters? Has this semi-orphan no claim to respect—no claim to a bit of the apicul-

tural world—no claim to be considered within the apicultural pale, although he may be elevated to the dignity of fatherhood of a few royal ladies? Or is he to be always the outcast and beggar in beedom?

The fact is that the drone is as much royal as the queen. He carries all those jewels of character possessed by his mother *and* father. He, therefore, is worthy of a place in the apicultural sum, and while we have no desire to remove the queen from her exalted position, we certainly do think that if she is to retain the crown, he, at least, should receive a coronet.

Testing the Drone

Since the drones of the two lower classes are absolutely useless for breeding select stock, the problem presents itself to us how to eliminate them and fly those drones that are from queens the equal of the L2 mother hen. We cannot test the drones as we can the cock, since the drone by his first act of nature, loses his identity through being absorbed by the queen. But consider well: *we have already tested the drone—through the worker which was the unreproductive sister of his reproductive mother.* Therefore, when we test workers, we are not testing future queens, but future drones. From this we get an insight

into the difference between breeding the bee and breeding other live-stock. In the latter, we test the breeding value of a male through his daughters: in the former, the bee, we test the male through his unproductive blood-sisters, *before he is born.*

Meaning of the Term "Test" Applied to the Queen

Here we might with advantage refer to and explain the term "test," as applied to the queen-bee. There seems to be a widespread misunderstanding of the application of that term, which is due to its use in two different circumstances. When a bee-keeper purchases a "tested" queen, he gets one whose worker progeny has been examined to ascertain whether she mated with a drone of her own race or to a drone of another. From that it will be seen that a tested queen need not necessarily be one that has purely mated, although that is accepted as being included in the usual meaning of the term.

The other occasion on which the term "test" is used is one where the reference is to the determination of the qualities and characteristics of the queen's worker progeny. Such a queen has usually been previously tested for purity of mating. But now it is desired to know the value of her progeny, and therefore this test is of lengthy

duration: in fact, it cannot be completed until the queen has passed one winter and one surplus-gathering period at the head of a stock that consists entirely of her own worker progeny. It is imperative that the two periods—winter and summer—be covered in the test, since during those periods the possession or otherwise of different qualities are proved. In winter, her progeny is tested for conservation of stores; stamina as disclosed by the number of dead bees on the floor-board; while she is tested for early breeding. In the summer the queen's worker progeny is tested for performance, such as nectar-gathering and comb-building, and for qualities such as swarming propensity and disposition.

Those queens that are tested for purity of mating are sold by the breeder to apiarists; and those queens that are tested for performance and characteristics are tested for breeding purposes. It is with the latter meaning that the term is used in this work. Should an apiarist desire to purchase a queen that has been tested for both purity and performance, he would have to purchase a "breeding" queen.

The Position of the Worker

In the worker we have represented the blood and qualities of the other castes: *virgin* queen

and drone. The drone, however, is not in evidence until the virgin queen, who, in so far as actual blood is concerned, is really his sister and not his mother, as is so frequently stated, has become mated. Therefore, to get the full benefit of those qualities possessed and exhibited by the workers, we must raise reproductive sisters to them, mate these virgins to drones from queens tested and raised in a similar manner the previous season, and in the following season fly drones from these young queens. The drones, except for a slight variation caused by the drone that mated to the queen from which they came, will be fully representative of the blood and character of the workers tested the past season. By breeding through the drone and flying only drones thus bred, the possibility of variation is reduced to a minimum, with the result that stocks become more even in character and more even in ability. Such methods of breeding and mating may be termed "concentrative" since superior qualities are being continually added to those of the stock.

The Parentage of the Drone

It is rather regrettable as tending to obscure the true position and possibilities of breeding, that it should ever have been taught that the

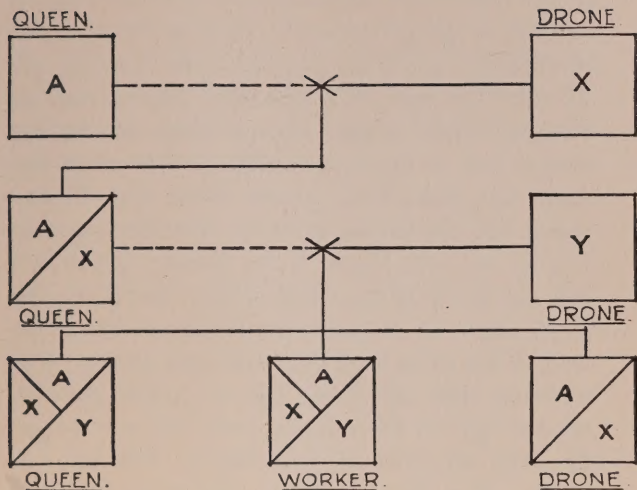


FIG. 17. DIAGRAM SHOWING THE ACTUAL DESCENT AND BLOOD RELATIONSHIP OF THE THREE CASTES.

The queen and worker progeny have 50 per cent. of the blood of each parent.

The drone progeny has the same blood as his mother and is therefore by blood one generation behind the queens and workers from the same mother, i.e., as if he were his mother's brother.

Note: If the drone is of the same blood as his mother, it necessarily follows that he must have the same parentage as his mother—that in the actual blood line the father of the mother is the father of the drone so that the drone on his father's side is one generation behind the queens and workers produced by his own mother. This proves that the drone has a father, although in the actual line of descent the father of the drone occupies the position of grandfather.

drone has no father. For breeding purposes it is not true. He comes from a female that, of herself, is one of the same blood as he, and she, therefore, is more his sister than his mother. If we take the case of a mismated queen—say an Italian—which mates with a black drone, her drones will be pure; but take another step and mate the cross-bred queens from this Italian queen and the drones of those cross-bred queens will be half the blood of the Italian queen and half the blood of the black drone; therefore, the black drone is as much the father of the cross-bred drone as he is of the cross-bred queen. The teaching that the drone has no father restricts the thought to there being only one way to get an even mixture of two bloods, through the queen. But that is not the only way; neither is it, if the cross is to be made permanent, *the* way. It can and should be done through both queen and drone, and where so obtained is of great value to the breeder, since he can accomplish through both drone and queen carrying double blood, what he cannot do with only the queen so conditioned. It is easy to get two bloods into a queen, but to rely on the female side alone will soon result in their loss. For as soon as her daughters mate, half the double blood disappears to be replaced by half that of the mating

drone. But these same daughters' drones are of the desired double blood, and advantage can be taken of that fact by changing the breeding from the queen to the drone. A word of caution is advisable here. In this talk of double blood, reference is made to two strains of the same race, and not to two races.

CHAPTER XII

MAKING A STRAIN

The Purpose of Systematic Breeding

Systematic breeding is followed for the express purpose of increasing the economic value of a stock. It embraces all that relates to or is employed in the making of a strain: to the method of breeding where the operations are directed to finding the best individuals in the stock and the occasional introduction of outside blood; and to line-breeding where the actual selection of individuals is restricted to those within the family and no outside blood is permitted to enter.

In this chapter we propose to deal with such principles of systematic breeding as applying to the making of a strain, and in a succeeding chapter with some principles that apply to bee-breeding generally, and a system of line-breeding applicable to the honey-bee.

When the apiarist determines to breed a strain of bee that shall be entirely of his own making,

he will most probably be already in possession of the stock that will be its foundation.

Of the characteristics and capabilities of that stock the apiarist will be fully cognizant, and he will be aware that the stock probably possesses some characteristics not desirable and that should be eradicated, while others of a desirable nature should be fixed to prevent their loss.

Fixing Desired Characteristics

The fixing of any particular characteristics is a matter of some considerable importance and a task of considerable magnitude. To be of value the method employed must be rapid, and at the same time its effects must be of a permanent nature.

It has been suggested that where some desirable quality has been discovered, all other stocks must be sacrificed so that the particular quality may have a chance to become fixed. The sacrifice, however, of other stocks is entirely unnecessary, and the less the breeder depends on chance to fix any character, the less regret will he have for wasted time and labour.

When a stock is found to be possessed of a valuable character, the object of the breeder should be threefold: to get the character into the drone: to fix it by inbreeding: and to spread it,

as soon as possible, throughout the whole apiary.

In taking the first step in breeding to fix the character, namely, getting the character into the drone, the apiarist should be careful that he employs no method that is likely to influence the quality in an adverse manner, either by diminishing it in intensity, or by losing it entirely. To accomplish that object he should inbreed.

Prejudices Against Inbreeding

Since there is a certain amount of prejudice against inbreeding, it may be as well to meet any objections here. Where inbreeding has failed to achieve the desired object, it has been employed without sufficient knowledge on the part of the breeder. We inbreed to concentrate special qualities in a few specimens, but inbreeding will concentrate both good and bad qualities. The preliminary essential then, is to be absolutely certain that the selected specimens possess good qualities and none others that will nullify them. Inbreeding alone will not bring success, but inbreeding combined with a rigid initial selection will. This is where the majority who have failed to derive benefit from it have made a fundamental mistake—they have not properly selected the specimens in the first instance.

It is frequently asserted that inbreeding will

reduce both size and stamina of the creatures so bred. The careful reader, however, will remember what was said about stamina elsewhere, and will readily see that actual breeding has very little to do with it. As regards the reduction in size, we have abundant evidence to disprove this contention. Darwin mated brother and sister for fifteen successive generations and doubled the size of his birds. Dr. Crew has inbred brother and sister of a strain of white rats for over sixty generations without loss of size or stamina. In those cases the foundation stock was properly selected.

There is no domestic stock that has reached a high degree of excellence in its development that, in the process of its making, has not been inbred to some extent. Inbreeding is the quickest and surest method, in fact, the only method, of fixing any desired quality, and if the breeder will not use it, he is refusing the assistance of a tool that, properly used, will save him years of unremitting toil.

There is no other stock of whatever nature in which the ill-effects of injudicious inbreeding is less likely to occur than in the bee. And where a proper initial selection is made and the breeding judiciously applied, we are firmly convinced that no ill-effects will follow.

The closest inbreeding with the bee that the average bee-keeper is likely to make is that between the drone and a virgin from the same mother. Many would say that those were brother and sister and should not be mated. But the best of poultry breeders do mate birds of that relationship where it is desirable and necessary to fix a superior quality.

The drone and virgin from the same queen-mother, however, do not carry the relationship of brother and sister. The drone is of the same blood as his unmated mother, but the other castes from her have only half her blood. The drone is one generation behind the virgin from the same mother, and he is more in the relationship of an uncle to a niece. There is a difference of fifty per cent in actual blood of a virgin from a queen as compared with the latter's drone. And since some of the best poultry breeders annually breed still closer with the happiest of results, there is not much to fear where there is a difference of fifty per cent in the blood.

It is possible, however, to breed still closer than with a drone and virgin from the same queen. We can mate a drone to a virgin both actually carrying the same blood. And where one is making a strain and it is imperative that one retains a particular blood for a year or two,

perhaps three, this mating is of great importance, it being the only method by which the blood can be kept pure. Such a mating, moreover, lends itself to providing either queens or drones which possess the same blood.

To explain how this mating can be made may be best done through a swarm. A stock then swarms. The swarm is hived on a new stand and a young swarm-queen in the stock on the old stand eventually mates. Now that *young* swarm-queen carries in her drones exactly the same blood as do the virgins from the *old* swarm-queen. Therefore, if drones are flown from the young swarm-queen and these are mated to virgins from the old swarm-queen, the resulting fertile queens will carry the same blood in both virgin queens and drones.

On the subject of inbreeding with the bee, it is high time that a change of opinion should be made. Out-breeding is approved, yet, no matter the kind of stock, it is a curse in any breeding, and more so in the case of the bee owing to the peculiar position occupied by the drone. And furthermore, out-breeding is absolutely unnecessary. If that should be doubted, let him who so doubts remember that the highest authorities agree that the Cyprian bee has had no foreign blood added to its own for over three thousand

years; and a much similar position is found with the Sahara bee, and in some of the bees indigenous to the hilly countries of Southern Europe.

The Reason for Inbreeding

The principal reason for inbreeding with the bee is to avoid the loss of any valuable characteristics discovered in the workers of a particular queen. We want those qualities in the drone, and to get them there, we have to arrange a mating, the queen of which shall be a reproductive sister to the workers carrying the desired quality. These virgins should be mated to a drone from the same mother simply to avoid any loss of the special quality, or to avoid the introduction of an unknown and probably inferior quality, which is possible when queens are mated to drones from a queen other than their own mother. In these virgins there is fifty per cent of blood foreign, to some degree, to that of the drones with which they mate, and because of that difference no possible harm can result from such a mating, and the retention of the special quality is more certain. But there is another consideration. The special queen's mother must have been selected for some outstanding trait or quality, which will be fully represented in the drone of the special queen. Therefore, by inbreeding in the above

manner, there is not only no likelihood of any loss of superior qualities, but an actual intensification of those for which the queens were selected.

Having got the desired characteristics into the drone of the inbred queen, the next step is to breed so that the quality may be spread throughout the apiary through other selected queens. To this end virgins from a couple of queens should be mated to the special drones. These queens should be selected from among those in the family most distant in relationship to the special drones. The workers of these queens will carry fifty per cent of the blood of the drones possessing the desired quality, but the drones will be of the blood of the distantly related queens and, therefore, have none of the blood of the drones from the inbred queens. To get drones carrying the proper proportion of the special blood, we must go a step further by raising virgins from *one* of these last-mated queens and, still to avoid any outside influence, also mate them to the special drones. These queens will give us the required drones, which should be mated to virgins from the other queen carrying the double blood.

Frequently it is desirable and necessary to combine one valuable characteristic with an-

other of equal value. Thus there may be two colonies, one possessing the quality of docility, the other that of non-swarmling. These would constitute a capital combination, but the breeding should be made as previously described—by getting the two bloods carrying those characteristics in both the drone and the queen with which he mates.

Crossing Two Strains

When it is desired to cross two strains, the breeder should have clearly defined in his own mind the purpose for which he intends to make the cross, and what blood he will mostly want to use after the cross has been made. On the surface, it seems to make little difference how the two queens are crossed, but that is not so as a study of the accompanying diagram will show.

The Eradication of Faults

The eradication of any undesirable characteristics from a strain of bees could be accomplished by a process of continuous selection from the better individuals contained within the strain itself. But the process would be altogether too slow and tedious. The breeder would reap little or no recompense for the time, labour, and money expended, and the apiarist, who naturally desires as

CHART SHOWING TWO OPPOSITE METHODS OF CROSS BREEDING

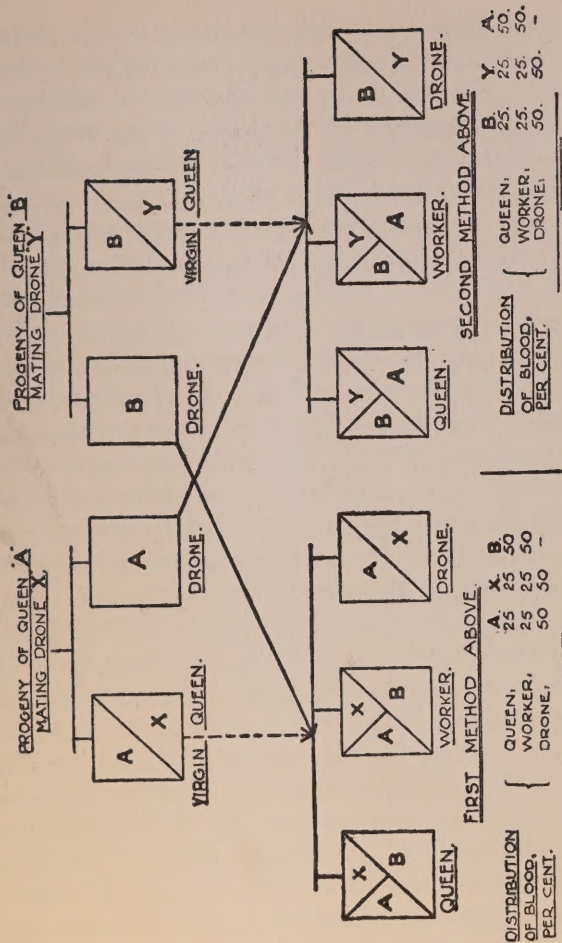


Fig. 18. Note: X and Y represent the blood of the drones with which queens A and B mated respectively.

good and as perfect queens as he can obtain, would have to wait many years for the production of queens of great excellence. Therefore, it becomes necessary to employ every means that will tend to expedite the achievement of the object the breeder has in view.

In the endeavour to breed out any particular faults in a black race, it is necessary to employ individuals of another race that possess characteristics opposite to those it is desired to eliminate. In the use of another race for this purpose the bee-breeder is more favourably situated than breeders of other stocks, since a cross-mated queen will provide him with pure males influenced, to some extent, in the desired direction by the drone that was used in the crossing.

The outside race so employed need not be used for crossing of a permanent nature. In fact, it is advisable not to do so, unless the breeder intends to make a new strain, or unless the faulty characteristic is so ingrained as to necessitate the actual addition of new blood to overcome it.

If the apiarist is satisfied with the working qualities of his own strain, it would be of no advantage to make another. He should, therefore, confine himself to the elimination of the faults he has discovered. By doing so, he will keep his race pure and will achieve his object much sooner

than if he set out to produce an entirely new strain or race with fixed characteristics.

The selection of the outside races should be according to the race in possession of the apiarist. If his bees are of the Italian race, he should select a strain of that race: where the race to be improved is a black one, then such races as the Carniolan, Caucasian, or French could be employed.

We are not favourably disposed to the crossing of the black and yellow races, especially where the permanent race is a black one. The yellow of the lighter races is so dominant to the black colour in the darker races that splashes and flecks of yellow will appear at unexpected times on the anterior segment of the abdomen of the black race so crossed. The breeding out of this yellow marking in the black races is very difficult. In the author's experience it has been the most difficult of all breeding operations. For several generations no, or scarcely any, mis-marking will occur, but suddenly the yellow will out-crop here and there. Where utility is the principal object, this mis-marking is not a weighty matter, but where it does occur it makes possible the accusation that the breeder's stock is not pure.

It is an easy matter to eradicate a fault in the

Italian or Golden Races since other strains of the same race carrying the desired characteristics are easily procured.

With the black races the matter is rather more difficult, since the breeder is almost invariably compelled to resort to the use of another race, which is frequently marked differently from that owned by the breeder. We shall, therefore, confine ourselves to a discussion of the breeding operations connected with the black races only. But as the principles are the same with any race, the apiarist who desires to apply them to the yellow races will be able to do so.

It may be that an apiarist has a strain of bee possessing good working qualities and not too much addicted to swarming, but rather warm in temper. He desires to alter that disposition and thereby make his strain good all round.

If docility were the only characteristic that such an apiarist contemplated imparting to his own strain, he would find the best way would be to do it through the Carniolan, assuming, of course, that his strain is of a black race.

In advocating the use of the Carniolan bee for this purpose, we do not suggest that the original strain be made into a cross-bred. If the original strain was good in other characteristics there is no need for any crossing of a permanent nature.

The procedure in such a case would be to fly drones from the Carniolan and cross these drones with virgins from the best queen of the original strain. The *cross-bred* worker progeny of these *cross-mated* queens should be thoroughly tested for the desired character—docility. In that test the behaviour of the bees under manipulation should not be neglected, for the bees will disclose much of their disposition when the hive is opened.

As an aid in making the test, the apiarist should take as his standard the disposition of the original strain. Some of the stocks will be found to possess the desired quality in a more pronounced degree than others.

In the following year drones should be flown from the *cross-mated* queen, whose workers have been mostly influenced in the desired direction by the crossing. The drones so flown will be of the original race. Those drones should be mated to virgins from two pure queens of the original strain, the ultimate object being to cross the drone progeny of one of these young queens with the queen-progeny of the other.

Success in this manner of breeding to impart a desired characteristic depends entirely upon the intensity of the fault and the degree to which it has become fixed. If the unwanted quality is

pronounced and has become firmly established, the process of mating just described may have to be repeated and perhaps again repeated.

So far, we have considered the improvement of a strain possessed of good working qualities, but a bad temper. Sometimes, however, we find a strain quite the opposite in character, being addicted to swarming, laggards in spring and never capable of working in a business-like manner, but of very gentle disposition.

Such a bee is very far from being a profitable proposition and almost invariably is the result of injudicious inbreeding for a particular quality—in this case, docility. The same can be said of some strains of Goldens, which have been similarly inbred for colour, their qualities not extending beyond the capacity to consume large quantities of food and produce many eggs. But they are very beautiful and, like all beautiful things, very expensive.

With such bees the obvious line of procedure is to breed in a manner the very opposite of the system of breeding that brought the strain to the condition in which we find it. Therefore, the proper method would be to out-cross or cross-breed; not, however, with the idea commonly supposed of adding greater energy, but to rouse thoroughly the sluggish nature of the stock.

Neither do we suggest the crossing to be of a permanent nature. The method to be employed is exactly the same as was suggested for the elimination of a bad disposition. But in this case it is not necessary to get a bee the very opposite in character of disposition—viciousness. What is wanted here is a bee possessed of vigour.

The bees of the particular characteristics we are now discussing usually belong to the yellow races; and as those races contain strains possessing the most opposite characters, it would not be difficult to find a strain with vim enough to do the rousing.

With the black races the only one that comes near the possession of the same qualities is the Carniolan. A similar procedure could be followed as in the case of the yellow bee, substituting, of course, a black race to do the rousing. In the selection of a race for this purpose, a strain of Dutch or French bees would be useful.

If the apiarist wished to retain his race or strain, he should breed exactly as was previously suggested—fly drones from cross-mated queens and mate them to virgins from a queen of the original strain or race.

He could, however, extend the breeding with advantage by crossing virgins from the *cross-mated* queen with his own drones. The queens

and worker progeny of these *cross-bred* queens would possess seventy-five per cent of the original blood. The apiarist could again mate virgins from these cross-bred queens to his original drones. He could continue in this manner to breed out the outside race until the marking showed its entire elimination.

Preparation of the Strains for Line-Breeding

The foregoing has reference to the apiarist who desires to improve his race or strain for his own use only. If he contemplates improving his strain with the ultimate object of entering the ranks of the professional queen-breeders, he will have to consider the matter from a different angle. He can, however, if he so chooses, breed as previously explained, and gradually introduce new blood as considered necessary. In that case however, he would lose his original strain, because of the continuous out-crossing. Where cross-breeding is practised, there can be no established strain. By introducing new blood the strain is at once destroyed. At the same time, a strain can be made by the combination of the blood of several races or other strains of the same race.

If, on the other hand, the apiarist contem-

plates line-breeding, it is advisable that, when improving his own strain, he so arranges his breeding as to reduce the necessity of introducing new blood to the lowest possible point after his line has been established.

If he decides on using a couple of queens with which to start his line-breeding, a little reflection will soon convince him that that number is insufficient. Therefore it is suggested that he aim to commence his line with three queens, in which case the apiarist will have to procure either two queens each of a distinct strain, or two queens each of a distinct race; making three with his own strain.

If he is working with the Italian bee, then two strains of that race would be suitable. If, however, his original race is black, he should select a queen from each of two races. This is suggested because his selection in the latter case is restricted, and because the inclusion of two strains of a black race would probably accentuate any undesirable characteristic it may possess.

The selection of two strains of either the Dutch or Carniolan would certainly tend to confirm and fix the swarming habit. Therefore, we should prefer in such a case to use two races: one, the Carniolan for the desired quality of gen-

tleness; the other from among those races having a tendency towards non-swarming, such as some strains of the French.

In such a selection the quality of gentleness in the race with the non-swarming tendency need not be very pronounced, as any deficiency in that quality could be regulated by the breeding through that race having the better disposition.

Having chosen and procured the extra queens, he should balance the characteristics of all the queens' progeny in the manner previously described. In this procedure he should not be too exacting regarding the crossing and mixing of the blood of the different strains. The principal requisite is to have the progeny of all the queens carrying as near as possible the same characteristics. Should this be neglected, there is a great probability of trouble arising after the line is commenced, whereas care in the preparation of the queens to start the line will eliminate that probability. Of course, care will also be taken in any crossing that the blood of any strain is not entirely obliterated.

It will be remembered that we previously advocated, where two strains are to be evenly mixed, to get the double blood into the drone. To do this, it is necessary to raise virgins from one of the two queens and drones from the other

queen. These are crossed and when tested daughters are raised from the young queens and mated to the same drones. This last mating brings the double blood into the drone in equal proportions, but seventy-five per cent and twenty-five per cent of the blood of the drone and queen respectively into the workers.

Crossing the Strains

An investigation into the crossings that are possible with three strains and aiming at seventy-five per cent of the original blood in the workers of each strain, reveals the fact that six groups are made, that the six groups naturally divide themselves into two sections, and that the crosses carrying the seventy-five per cent of blood, also carry twenty-five per cent of the blood of one of the other two strains. The sections divide themselves as follows, and each of the two sections carries the full blood of the three strains:—

1st section:	$\frac{1}{3} +$	$\frac{2}{1} +$	$\frac{3}{2} +$
2nd “	$\frac{3}{1} +$	$\frac{1}{2} +$	$\frac{2}{3} +$

In the above explanation the fraction represents the blood carried by the worker progeny of a particular mating: the numerator of the fraction represents the drone blood, and the denom-

inator the queen blood. The plus (+) sign indicates the possession of seventy-five per cent of the original blood of the strain to which it is attached as shown by the numbers.

It does not follow that, because a chart has been given showing the method of securing the proper proportion of the blood of two strains in the drone and queen respectively, the breeder is to make the whole of the crossings. It will sometimes be found unnecessary to cross all three strains. A combination of the desired qualities may be secured by only one crossing, but it all depends on the characteristics possessed by the new queens purchased to commence the line. In any case it will be necessary to test the new queens and, if found satisfactory, to cross their daughters with drones of the foundation stock. In making this cross the breeder achieves a two-fold object: it enables him to ascertain to what extent the characteristics of the new queens' progeny is influenced by his own drones, and at the same time, it provides him with breeding queens whose drones are representative of the workers of the new queens he tested. With such queens in his possession he is master of the situation. He will know exactly what characteristics are carried by their drones, which he can use for mating purposes as his breeding may demand. And if he

has not previously bred in this manner, he will be pleasantly surprised how rapidly and to what extent his breeding can be influenced.

The Elimination of the Swarming Tendency

The elimination of the swarming tendency is a problem of another order, since the apiarist can do little or nothing of an active nature towards its solution.

In the attempt to control or eradicate this impulse, we are not at all satisfied to depend on frequent manipulation and reversing of chambers, combined with the removal of queen-cells. These practices do nothing of a permanent nature to overcome the tendency, and where an apiary is fairly large are not business propositions.

In attempting to eliminate this proclivity we are up against a problem entirely different from that of a faulty disposition. Here the characteristic is of such a nature as to preclude any attempt to breed it out at the start. The only indication of a probable tendency to swarm is the raising of a large number of drones, but since this is altogether a too narrow base on which to establish our breeding, we are compelled to call in other aids, which must of necessity be of another nature. And it is only when the bees respond to those aids that the apiarist can consider

the question of breeding to further influence this characteristic in the desired direction.

The primary object of the apiarist in this matter should be the breaking of the habit; and to gain that object he should employ any means of whatever nature that will contribute to that end.

In discussing other undesirable characteristics there was no need to enquire into their origin or cause. Here again the case is different; for owing to the obscurity of the subject, we are compelled to make an effort of discovery if only to provide ourselves with a working hypothesis.

Among the many factors that are said to contribute to the swarming tendency there is one that is always present; a congested condition of the brood-chamber, which has been finally accepted as the real cause.

A Suggested Cause of Swarming

We believe, however, that it is not so much the actual congestion of the brood-chamber, as the heat generated by the bees within the hive. This heat is increased by very warm weather until the conditions within the hive resemble a miniature Black Hole, and become so unbearable as to cause the bees to make preparations towards obtaining the only means of relief—swarming.

That theory is not upset by swarming taking

place in cool weather. Preparations are made some time beforehand, and it is well known that when once the bees commence the execution of a purpose, they seemed compelled by natural tendencies to carry it to a conclusion, despite the fact that the conditions that called forth that purpose no longer exist.

We further believe that some stocks, like some human beings, can tolerate a greater heat with far less discomfort than others, and that if the heat does not reach the limit of their endurance there will be no, or little, swarming.

That congestion of the brood-nest is not the actual cause of swarming is indicated by the concentration, to a degree of congestion, of the bees in the brood-nest where excessive ventilation has been provided. In that case more than sufficient opportunity has been given for the escape of the excessive heat, with the result that more bees are recalled to the brood-chamber to maintain the temperature necessary to the welfare of the brood.

Then again, we are confronted with the fact that swarms are usually larger in very hot weather and smaller in cool. This, in our opinion, also points to heat being the decisive factor.

Still further, we have proof of the beneficial effect against swarming of the wider spaced

frames, which make possible the more rapid escape of the heat from the brood-nest.

The Need of Abundant Ventilation

For many years we have been convinced that the necessity of thorough ventilation in the hive has been to a great extent ignored, simply because we have had no adequate idea of the bees' requirements in this matter. That bees require huge quantities of air circulating within the hive was abundantly proved by the experiments conducted at the Iowa State College, U.S.A., on July 6th and 7th, 1923.

An American Experiment

In that experiment the stock itself forced through the hive in one hour 807 cubic feet of air. That is much more than is contained within an eight feet square room with nine-feet walls, such a room containing only 576 cubic feet. While the greater quantity of that air was probably required for evaporating the newly-gathered nectar, it is more than probable that a large quantity was also needed for cooling purposes.

Although that experiment was most valuable, we believe it should have been checked by another conducted under similar conditions, but at

a time when little or no nectar was being gathered. The results of the two experiments would have given a more accurate indication of the purpose for which the bees required such huge quantities of air.

Methods of Providing Full Ventilation

It is suggested that in the first year the provision for ventilation should be on the excessive side. We have derived great benefit from the use of a double entrance—one at the front, and one at the back. Where the apiary has a little shelter from the south-west winds good results can also be obtained by the insertion of a one-eighth inch strip of wood (pieces of broken section do well) between the first extracting super and the brood-chamber. This strip of wood should be used on both sides so as to allow a current of air to pass over the brood-chamber from back to front or *vice versa*.

In raising the supers in the above manner, one-eighth of an inch only, the bees themselves are able to adjust the aperture and, therefore, the ventilation. We find this method much better than simply staggering the supers. We believe that the latter method is not effective to any appreciable extent. If the supers are pushed back, the opening is at the front, and in our

opinion simply allows a current of air to pass upwards from the entrance between the nest and the wall of the hive, and then out. It is similar where the opening is at the back. The air passes along the bottom board, up between the nest and the hive wall, and then, as before, out.

After the bees have responded to such methods the ventilation in the following years could be reduced by inserting a piece of similar wood between the supers and the brood-chamber towards the front only.

Where the apiarist has about half a dozen hives, a good procedure would be to provide for ventilation by using different methods—each method to be applied to a pair of hives. In this way he might find a stock or two that would respond to the lesser amount of ventilation, and his obvious course would be to breed from those stocks.

When the apiarist is running for comb-honey and is using such methods as described, it will be found that those sections nearer the apertures will not be sealed as rapidly as others—in some cases they will not be sealed at all. But the apiarist need not worry about that. He can give those incompleated sections to a stock just before the close of the flow, and leave them on the hive for some time after the flow has ceased. The bees

will complete these sections even to the extent of carrying honey up from the brood-nest. If, however, the apiarist has achieved his object, he will have gained more surplus than would have been the case had his bees swarmed, besides which, he has been relieved of the trouble of hiving the swarm.

Towards the close of the honey flow and when the swarming trouble is no longer a probability, the strips of wood used can be removed and the hive allowed to resume its normal condition.

The Influence of Undue Manipulations

There is another factor that has great influence in both establishing and confirming the swarming propensity. It is excessive and undue manipulation. Frequently and repeatedly stocks are opened up when the owner has no "business" with them; it is just a part of a hobby with no thought of the welfare or comfort of the bees. We believe that not one apiarist in a hundred is aware of the harm done by too frequent manipulation, not only in connection with the question of swarming, but also with that of altering the disposition of the bees for the worse.

In this matter the owner is his own enemy. Especially is this the case where the hive is opened up in early spring. At that time warmth

is a food-equivalent and the dispersion of that essential warmth by opening the hive is just as if the owner threw either honey or sugar into a ditch.

It may be retorted that opening up to some extent is necessary for spring-feeding. To which we reply that there is no need to remove even the roof for that purpose. Feeding should be carried out from beneath the stock. This can be done in an economical manner—economy in food and economy in expensive feeders.

The apiarist should arrange that his stocks go into winter quarters with a seven-eighths inch space beneath the frames and between them and the floor-board. He should also arrange the entrance so that at any time he can insert a shallow feeder beneath the frames. This is the author's method and the feeders he uses are just ordinary sandwich tins. These tins are about nine inches in diameter, three-quarters of an inch in depth, and hold nearly a pint. Those used by the author have a tongue soldered on the bottom at one side. This tongue remains outside the hive and enables the tin to be withdrawn for refilling purposes.

If a bent piece of cardboard is used as a funnel when giving more food, the tin need not be entirely withdrawn from the hive unless the apiarist is impeded by a porch.

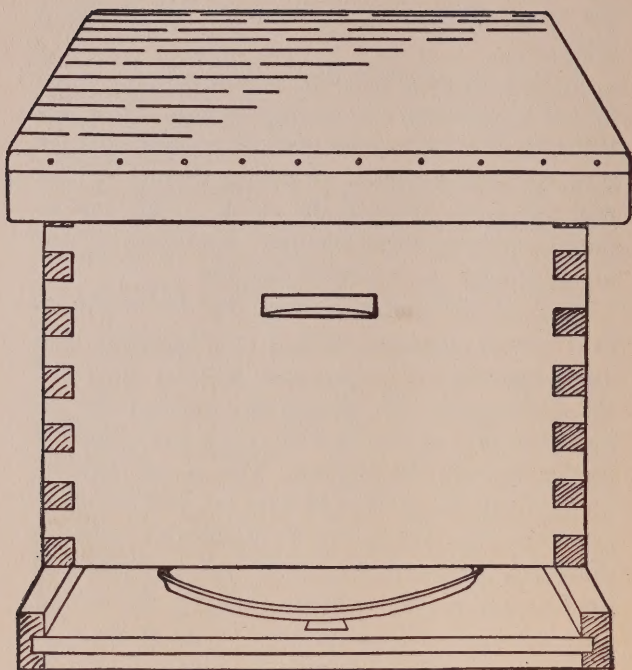


FIG. 20. Hive with shallow tin feeder.

The cost of these tins to the author was two-pence half-penny each. They have been in use for five years, and another five years service is expected from them. If lump sugar is used with the syrup, no bees will be lost by drowning.

The Provision of Shade

But to return. A matter of some importance in reducing swarming and one that agrees with the author's heat theory, is shade. A good method of providing shade is by the use of an old sack on the side of the hive exposed to the mid-day sun. A sack is easily handled, takes little room in storing, suffers little in damage and is cheap.

The Stimulation of the Storing Instinct

The apiarist can further assist in overcoming the swarming tendency by building up the storing instinct. This can be done by a system of special feeding. We like to arrange our winter stores so that there will be about ten pounds of food in each hive at the beginning of March, and we find that strong stocks in the Jumbo Langstroth hive with nine frames will need about thirty to thirty-five pounds of food for this object.

We know that a huge amount of food—eighty

pounds of food per stock has been suggested—is considered necessary to take a stock over the winter and well into the spring. That quantity, however, means somewhere about fifty pounds of food in the hive at the opening of the season. We prefer to have a much smaller amount for two reasons. First, the queen has a large amount of empty comb in which to lay, thereby making possible a huge population according to the amount of feeding: secondly, the presence in the hive of such a large quantity of food does a great deal to destroy the storing instinct which the breeder should do all he can to stimulate until it becomes a fixed characteristic.

During the early spring when the weather is inclement and many bees are lost when flying, we prefer to feed slowly diluted honey or sugar syrup. This is looked upon by some as unnecessary labour, but we believe it to be one of the most payable propositions connected with spring management. Objection, we know, is also taken to the time involved in feeding a fair number of stocks. But when time is worked out the objection falls lifeless to the ground.

A three-gallon bucket will hold enough feed to give thirty stocks a little under a pint each, and if the sandwich-tin is used as a feeder in the

entrance of the hive, the actual feeding can be done in about fifteen minutes. If the entrance is elaborate, it might take longer, but even then the time spent is well repaid by the obtaining of much stronger stocks.

When the season begins to warm up, the syrup feeding is changed to candy feeding, the object being to compel the bees to gather water with which to dissolve the candy for feeding the larvae. This activity builds up the storing instinct.

For candy feeding we use the sandwich tins which had been previously used for syrup feeding. These tins are filled with candy and inverted over the feed hole, or can be pushed under the frames through the entrance, as was done with the syrup.

Breeding Out the Swarming Tendency

We now come to consider the breeding side of the question. In dealing with this part of the subject, we are fully aware that the consensus of opinion is against the possibility of breeding a non-swarming bee. Why that is so, is difficult to understand. It is probably due to the failure of previous attempts, although we are satisfied that success has been achieved in several instances. Where the failure has occurred has been

in the subsequent handling of the queen and an insufficient understanding of the position of the castes in the stock.

A breeder raises a strain and is satisfied that he has developed the non-swarmling tendency. He advertises his queens and sells them as non-swarmlers. They are introduced to other stocks which eventually swarm and their failure in this direction confirms the prevalent belief of the impossibility of developing a non-swarmling strain by breeding.

The failure here is neither in the method of breeding, nor in the queen, but simply in putting the queen to head stocks that are still addicted to swarming. No queen, however bred, could alter that characteristic in alien bees.

The queen is a servant of the community within the bee-hive, and like all servants is expected and made to obey orders. Those orders are given by the workers, and are the result of the habits and characteristics bred into them.

It can be taken as an axiom that no queen, however bred, will rise above the characteristics of the stock she heads. And any tests for qualities are of no value unless the workers of a stock under test are the progeny of the queen included in the tests. Even then the workers are representative of only half the queen.

A phase of breeding that has received very little attention is the probability of the progeny of an alien queen being influenced by the workers of the stock to which she has been introduced. It should be remembered that all food supplies of whatever nature come from the worker. She supplies the queen with the food necessary for the production of her egg; she supplies the food necessary for the development of the larvae. In this matter we have both heredity and environment acting together, and it would indeed be next to a miracle if no characteristic was imparted to the progeny of the alien queen under such circumstances.

We believe that in time to come queens will be more frequently purchased with nuclei, and built up by the purchaser. It is by far the more satisfactory method of procuring queens and is the only sure way, under present methods, of the buyer discovering with accuracy the value of the queen.

It is claimed that swarming is a deeply seated instinct based on reproduction, and being such cannot be entirely eradicated. Undoubtedly, the production and care of young is a deeply implanted instinct and appears just one of those natural instincts that man cannot overcome. But a similar tendency has been overcome in an-

other species of live-stock. We refer to the common fowl, in which the varieties of light breeds have for many, many years constituted non-sitting breeds. When we look upon the stubborn tendency to sit in some of the heavy breeds, and appreciate the fact that all members of the domestic fowl sprang from the same race, and must, therefore, originally have had the sitting tendency, the prevalent belief that a corresponding tendency in the bees cannot be eliminated is inexplicable.

We believe the correct line in the attempt to breed out the swarming tendency is through the supersedure queen from a stock that has never swarmed. That the latter are difficult to procure is admitted, and it was for that reason that we advocated the use of any means that will tend to break the swarming habit. The supersedure-bred queen, however, may have to be waited for for some years and in the meantime the apiarist must take advantage of every help that offers itself. If he has had a queen or two respond to the methods employed to break the habit, he can breed from the best queen and then put her in reserve until her stock either swarms or supersedes her. In the latter case, he should practise in-breeding with the young supersedure-bred queen and then fly drones from the young queens raised

from her. He should retain these daughters from the supersedure-raised queen as long as possible, and mate their drones to any other queen that did not swarm the first season at the head of a colony.

In the meantime, he should be alert for other supersedure-bred queens, and when found, breed in exactly the same manner.

He should keep a watchful eye also on the number of drones a colony raises. If he comes across a stock that restricts its breeding of drones, it is another point to note, should that stock be one of the colonies to respond to the preventive measures.

CHAPTER XIII

PEDIGREE OR LINE-BREEDING

What Line-Breeding Is

Line-breeding is another name for pedigree breeding. Both imply that the strains have to some extent been inbred; that is to say, that the breeding is kept within the one particular family.

The importance of pedigree or line-breeding cannot be exaggerated. It is the one means by which the superior qualities of a strain can be handed down to future generations, and the only way in which a strain can be kept pure, using the term "pure" with reference to qualities only.

Unless there is inbreeding there cannot be pedigree breeding. Crossing at once breaks the strain; by which we mean a family, the individuals of which can be relied upon to breed true to a standard of qualities formulated in the breeder's own mind and fixed in his own stock.

It was previously stated that the object of the breeder was to increase the economic value of his stock. But in itself, that is insufficient.

Unless some means are discovered and utilised so to arrange the breeding that there shall be no wide difference between individuals, a great many of the breeder's efforts will go for nothing. In any stock, the members of which vary considerably in their utility characters, we have the high economic value which is carried by the better individuals, reduced by the lower value of those carried by the poorer. Therefore, the breeder's object should embrace the production of queens whose progeny vary in characteristics as little as possible from those that form his standard. This can be achieved only through line-breeding.

Indiscriminate Mating

Line or pedigree breeding is looked upon with disfavour by some who imagine that indiscriminate crossing will ultimately produce the ideal bee. That attitude is most unfortunate and is the result of a want of knowledge of the subject. There is not a single kind of stock of an economical value to man whose value has not been produced and increased by line-breeding. Milch cows that win butter and milking competitions have been line-bred; poultry that win laying competitions have been line-bred; and the cattle that walk off with the prizes at the

Annual Cattle Show have also been line-bred.

All these successes have been achieved by intensive selection from within a particular strain or family for many, many generations, and in some cases for well over a century, and could have been gained by no other means. Is it then seriously suggested that nature unaided by man is going to evolve a bee the equivalent in quality to those prize winners? Nature did not do so in those cases and why should she be expected to do the exceptional in the case of the bee? That an ideal bee may be evolved by itself is a supposition that is disproved by every bit of breeding experience, and to persist in maintaining a proposition to allow nature to work alone to produce the ideal creature of an economic value to man is only trifling with the subject.

The Fertile Queen

The honey-bee, by the peculiar circumstances that make the fertile female really the equivalent of a pair—male and female—lends itself admirably to a system of line-breeding. A superficial examination of the true position occupied by both the drone and the queen, however, would give an impression that the very opposite was the case.

We have already discussed the advantage obtained when the male is made the dominant breeding parent. But breeding solely through the male would entail the loss, or delay the fixing of some desirable qualities, inasmuch as only a portion of the blood in the apiary would be used. This possible loss is something that the breeder should guard against. He should miss nothing in the way of superior qualities possessed by any individual, and his system of line-breeding should be such, that if to it he will rigidly adhere, it should almost automatically include all those qualities that conform to his ideal.

Difference Between Line-Breeding the Bee and Other Stock

The important question now arises, "How are we to line-breed?" If we desire to do so on the principles that govern the line-breeding of poultry, we shall soon discover that that system is not applicable to the bee; that we cannot take the second step without finding ourselves up against a stone wall.

In line-breeding with poultry it is the usual practice, after the first mating, to mate back a daughter to her father, and a son to his mother. In bee-breeding those matings cannot be accom-

plished, because the mother is already fertilised for life, and the father no longer lives. Of course, a daughter can be mated to a drone the equivalent in blood to her father, and likewise can a son of a daughter be mated to a virgin queen carrying the same blood as his mother. In the latter case, however, an analysis of the blood relationship reveals the fact that their blood is identical, and, therefore, cannot be used together; except for the purpose of very occasional inbreeding, where it is absolutely necessary to fix a quality before it gets lost.

In breeding the bee, we should ever remember that the progeny—drone, worker, or virgin queen—of any particular queen consists of two generations, not one, and, therefore, we must devise a system that shall conform to that peculiarity. Perhaps, before going further, we should say how the progeny from a queen consists of two generations. It is said that the drone is the son of his mother only—the worker and virgin queen are descendants of both mother and father, and, therefore, representative of a generation that is one step more advanced than that of the drone. In other words, the drone is one generation behind that of his sister, whether worker or virgin queen.

The principle to be borne in mind is to get any

special qualities in the worker imparted to future progeny. We have shown that this is impossible where we attempt to do it through the queen, and therefore, we must, of necessity, do it through the drone. This principle should govern all our breeding operations. The drone is undoubtedly the dominant breeding parent, and by breeding through him, we must indelibly impress his qualities as desired. Bearing that fact in mind, and desiring a system that has simplicity as its base, and one through the use of which all characteristics of value are imparted to the progeny, the author devised the following method. He is aware, however, of other systems of line-breeding, but in most cases they entail the raising of two or more strains of drones annually, and the addition of new blood to as many strains as the breeder keeps. All such intricacies the author has endeavoured to overcome. He flies only one strain—that constituting the line—of drone yearly, and by commencing with three queens finds the addition of new blood to be unnecessary for many years.

Renumbering the Strains

When the breeder commences his line-breeding, he will find it necessary to alter the number of the strains, one of which may stand out as

possessing, to a high degree, some particular trait or character that is desirable to extend still further to the other two strains or races. As, therefore, number three queen or strain, as numbered for the line, is the queen whose drones are first used to cross the queens of both the other strains, it is advisable that the queen possessing the special trait should receive that number.

There is also another consideration. The drones of number three queen will be half and half of the blood of the parents shown by the fraction representing worker progeny of a particular mating with seventy-five per cent of original blood. This is a point that should not be missed by the breeder. He may have one of the strains with a non-swarming tendency and another strain showing docility. These would constitute a happy combination, and one that would repay him to use, and his best means of doing so is through the drones carrying those characteristics in equal proportions.

When the breeder does renumber his strains for line-breeding, he must forget all the old numbers; otherwise his breeding will become confused.

The System of Line-Breeding Explained

We now proceed to give a full explanation of

the system of line-breeding herein advocated, and in doing so the author would suggest that the reader uses the line-breeding chart in conjunction with the explanations.

The breeder having decided upon three queens to commence his line, numbers them, 1, 2, and 3 respectively. These queens are represented on the chart by the squares so numbered. It might be as well to state here, that the squares represent single queens selected from a group carrying the same number. The group is represented by a circle, each of which with its number represents the result of one particular mating. The heavy lines on the chart show from what queens the drones come, and the dotted lines show from what queens the virgins come; the results of that mating are shown by the circle where the two lines meet. The straight line from queen 3 to group 15 shows the true line of the strain, and all circles on that line denote the drone breeding groups, the line being taken through the drone and not the queen. In keeping with the principle that the breeder should miss nothing of value in his breeding stock, the drone-groups also supply queens, but at a time different from that when drones are flown from the same group. By this method of using both drones and virgins from the same mother, no character

of an economic value is lost; in fact, they tend to become firmly fixed in the strain. The system also enables the breeder to give individual attention to his queens, because of the small number in each group, and he thereby gets to know more about particular matings and eventually his strain, than he could do were no such system employed.

In the *first* year drones are flown from No. 3 queen and mated to virgins from Nos. 1 and 2 queens respectively. Each of these matings is shown as a separate group and numbered respectively 4 and 5. In the *second* year drones are flown from No. 5 group and mated in June to virgins from No. 1 queen. This mating becomes No. 6 group, and during the year following that in which it was raised is tested for character and performance. In the meantime, the queens comprising group No. 4 have been undergoing a similar test, and at the end, or just before the end of the honey harvest, a selection from the queens of that group is made and virgins from her raised and mated to the drones of No. 5 group. This last mating is number seven and supplies the drones for breeding purposes in the following season.

Before proceeding further, let us pause to examine what actually takes place by crossing

the original queens in the manner described. In crossing the three queens we gain three new groups, 4, 5, and 6, and when we examine the composition of these new groups, we find the blood of each of the three original queens to be in two of the three new groups, thus:

No. 4 group	{	drone from No. 3.
	{	queen from No. 1.
No. 5 group	{	drone from No. 3.
	{	queen from No. 2.
No. 6 group	{	drone from No. 5. (this is
		really No. 2 blood).
	{	queen from No. 1.

We can show them another way, thus:

Nos. 4 and 5 groups each have No. 3 blood.

Nos. 4 and 6 groups each have No. 1 blood.

Nos. 5 and 6 groups each have No. 2 blood.
(No. 5 drone is really No. 2.)

To return, however. In the *third* year drones are raised from a selected queen belonging to No.

7 group. In June these are mated back to queens from No. 5 group and the queens of this mating form No. 8 group, and undergo a character and performance test as did the other June-raised queens. Towards the end of the honey flow, the queens of No. 6 group will have shown their capabilities, and a selection of a queen is made therefrom, virgins raised from her and mated to No. 7 drones. These young queens form No. 9 group, and provide drones in the next season.

Every year a similar procedure is taken. Drones are raised, and are the only drones allowed to fly during the mating period, from the group made the previous July. The drones are mated back to a daughter of the previous year's drone breeder, and at the end of July mated to daughters of a queen chosen on test from the previous year's June-bred group. Thus every year only one group supplies drones, but two groups supply queens.

Here we would anticipate a possible objection, and at the same time make the matter of mating back clearer. It may be urged that mating back drones of the previous year's breeding to daughters of the queen that provided one of the parents is bad from an inbreeding point of view. But let us see what actually is the case. For

example, take No. 5 drones which mate with No. 4 queens to form group No. 7. The following year No. 7 group gives drones that are mated back to a queen from No. 5 group. On the surface it does seem as if inbreeding of the closest nature had taken place; actually no such thing has occurred.

Taking the groups just mentioned, we ask ourselves, "From what mating, or from what blood, have the queen and drones come that are thought to be concerned in the inbreeding?" The virgin queens of No. 5 group consist of the blood of No. 3 and No. 2—half each. The drones from No. 7 with which No. 5 queens were mated, are of the same blood as the workers and virgins of No. 4 group, whose blood is derived from groups 1 and 3. Thus No. 8 group resulting from the mating of groups 5 and 7, consists of one-half No. 3 original blood, and a quarter each of the bloods of Nos. 1 and 2 groups.

The Problem of New Blood

It may be wondered what is going to occur when the line get fully established and no outside blood is introduced. Here we fall back upon a phase of breeding that has been so obscured by questionable teaching as to be almost lost to practice.

That loss has been occasioned by the advice, tendered with all emphasis, to re-queen all colonies annually, which advice was consequent upon the extolling of the superfecund queen.

The peculiarity of that advice, however, was that while the queen was considered as being worn out at the end of her first season at the head of a colony, and fit only to be discarded, there were no other queens, but those same worn out ones from which to raise other queens for replacement purposes!

The phase of breeding to which we refer is the retention of colonies of proven worth for the sole purpose of providing supersedure-bred queens, which have been almost entirely lost to breeding practices.

The Supersedure-Bred Queen

One may raise his queens by any method he chooses—he may double graft larvae with the object of raising superior queens, but he will not by any means produce the equal of the supersedure-raised queen. She has her equal nowhere! The nearest approaches to her in quality are the queens that have been raised from the egg in a colony that had unsealed queen-cells from which the royal larvae had been ejected, but in which the royal jelly had been allowed to remain.

But not only has the apiarist been deprived of the finest queens it is possible to obtain; he has also lost, with those queens, the possibility of overcoming, in the only way, that bugbear of bee-keeping—the excessive swarming tendency.

The apiarist who pins his faith to manipulation to prevent swarming, should he have both time and inclination to turn his hives upside down every seven days and cut out queen-cells, will reap no satisfaction for his trouble. In the first place, it is not entirely effective as a preventative, and it has no effect in eradicating it. Secondly, frequent manipulation is the one thing, more than any other, that will make the bees become inveterate swarmers.

It is not suggested that supersedure-raised queens will eradicate the swarming tendency immediately. If the bee-keeper will reserve those queens that did not swarm the first year of their heading a colony, until the bees either swarm or supersede the queen, he will have taken, if the bees do the latter, the first step to overcome the swarming tendency. And if he will practise for once in a way, inbreeding with those queens, and then use their queen progeny as drone breeders, he will do more in one or two seasons to overcome the excessive swarming tendency than many years of manipulation.

In making that suggestion, however, the author would remark further. Do not attempt to raise what are called supersedure cells above an excluder. The teaching that describes those cells as being raised under that impulse is an item repeated from Doolittle, who considered them so bred because he found the number so raised to correspond with that usually found in a brood nest when supersedure proper was taking place, and because he never knew a stock to swarm that had cells above an excluder and none below it. Those premises, however, are entirely inadequate on which to build a conclusion. Had Doolittle tested the matter further, he would have found that the number of cells raised above an excluder varies according to other conditions, both inside and outside the hive. Those conditions are: the amount of food in the hive; and the amount of nectar being gathered; the amount of brood in the upper storey; the number of nurses above, and the distance the upper brood chamber is from the lower containing the queen. Had he also examined the cells after the emergence of those supposed supersedure-bred queens, he would have found every indication of those cells having been raised under the queenless impulse, because they disclose the fact that larvae had been used which had been flooded out

with royal jelly, so that the cells could assume the pendulous position that seems necessary to queen-cells.

But, strange enough, we have the weightiest refutation of this matter from no less a person than Doolittle himself. In his work on *Out-apiaries* he gave a method of making increase from which the following is extracted, page 29: "I now take one of the frames having queen-cells on it, together with the bees on the same, and carry it to one of the hives having the tiered-up brood, taking from this a frame (bees and all) and putting the one with the cells in its place. In all this work with tiered-up brood, when changing the same from one hive to another, I do not disturb the bees on them, as *bees above an excluder are, to all intents and purposes, queenless*, so make no trouble by putting them in different hives." (Italics ours.)

It can be accepted that no queen is raised under the supersedure impulse unless she has come from a cell actually built on a comb to which the old queen had access, and a cell into which the old queen deposited the egg. All queen-cells raised otherwise are raised under the queenless impulse and for breeding purposes are worthless.

In the system of line-breeding herein de-

scribed, the supersedure queen has a double function. When a colony or two show qualities of a high degree of excellence, they are set aside in reserve until they either swarm or raise supersedure cells. Should they swarm, they are at once removed and replaced by other stocks that did not swarm during the queens' first year. The blood of the queen so put aside has ceased to involve in the line, whereas that of the line has gone on involving and intermingling; and the greater the interval between the reservation of a queen and the reintroduction of her supersedure-bred daughters into the line, the greater the difference in their blood and that of the line. By introducing supersedure-bred queens into the line, the breeder is achieving three objects: keeping to his original strains; doing the best practice to combat the swarming tendency; and introducing practically the equivalent of new but partially related blood, which is well known to be the best practice.

CHAPTER XIV

CONCLUSION

Past Improvement of the Honey-Bee

It is possible that some objections may be made to the somewhat revolutionary character of the teachings contained in this book, but to anyone who has had experience in stock-breeding, and who has embarked with breeding knowledge thus gained on the cultivation of the honey-bee, the present position of the bee and its breeding occasion some surprise and become subjects for consideration and comment. In all other cases of live-stock breeding the progress of late years has been astounding. In the case of the bee, however, there has been no proportionate progress, which, to some considerable extent, has been admitted, and which has been excused on the grounds of the bee being a more highly organised creature and less capable of improvement than other live-stock. But that excuse is hardly justified. There is no cogent reason for confining improvement to organism. When or-

ganism has reached a high degree of development, there is function to be cultivated to a higher standard within the limits of the creature concerned. With the bee and apart from organism there is abundant room for improvement in the way of qualities, such as stamina, surplus gathering, disease-resistance, and non-swarmling.

During the last half century, on the other hand, the progress made in equipment and in methods of manipulation has been out of all proportion to the improvement of the bee. For over forty years efforts have been made, within the limits of orthodox theories, to improve the bee, not in one country only, but in almost every advanced country in the world. And an unbiased survey of the conditions of apiculture during that period will lead one to no other conclusion than that those efforts have been almost negative in results.

Superfecundity and Disease

Should the reader point to the increased fecundity of our queens to disprove the contention that insufficient improvement in the bee has been accomplished, we reply that disease is an expression of lowered vitality; that an abnormal use of the procreative and nursing functions is a large factor, if not the largest, in the reduction

of stamina so necessary to such stock as the honey-bee, whose life can be summed up in the one word "work"; and that simultaneously with increased fecundity there has been an extraordinary increase of disease. Their connection may be denied. It may be said to be nothing but a coincidence. But when we find a similar occurrence taking place with other live-stock which we know to have been pushed for super-production, we consider the matter far more than a mere coincidence. That there are probably other factors in the case is admitted, but undoubtedly breeding for super-production is one of the most important.

Another fact of some significance is that during the period under review the increase of disease has occurred principally in those countries where modern methods of breeding have prevailed. In America brood diseases became so devastating as to call for legislation, in spite of which, however, the disease continued so much as to cause some advocates of legislation to declare against it. On the Continent of Europe apiarists have been troubled with *Nosema* disease, and, in a minor way, with bee-consumption. In Australia, bee paralysis is rife and has wiped out many apiaries. Coming then to our own country, we had I.O.W. disease, which so

decimated apiaries all over the country that we had to resort to foreign bees for restocking purposes. Similar was the case with Acarine disease, if it may be rightly called so, that followed in the wake of I.O.W. disease.

Assuming the accuracy of all present-day theories relating to bee-culture, the foregoing facts are inexplicable. More so, since we know that some of the best brains have been employed on research work in connection with the bee. That alone should cause us to re-examine our theories, especially those relating to breeding, for the only conclusion to which one can come, is that the principles on which the whole structure of modern apiculture is based must be at fault, in either one or more important directions.

Since no live-stock industry can withstand the ravages of disease and live, the question of bee-diseases assumes an importance that cannot be exaggerated. It is no use developing the economic value of a stock in one direction and having all labour nullified by a factor operating in another. And lest some should be inclined to question the author's conclusions as to the increase of bee-diseases during the period under consideration, it might be convincing to give an extract from Dadant's *System of Bee-Keeping*, page 107, where we read: ". . . If anyone had

asked us, twenty years ago, how much trouble might be expected from bee-diseases, we should probably have shrugged our shoulders and answered that they were very insignificant and hardly worthy of notice. For forty years after we began bee-keeping the only disease we saw in the apiary was diarrhoea . . . from which the bees suffered more or less after a protracted winter, especially when their food was not of the best. . . . Foul-brood, in either of its two different forms, was entirely unknown to us. In 1903 the writer had to go as far as Colorado to be able to see some rare samples of it. . . . It was not until the spring of 1908 that we found the disease among our own bees. . . .”

If that statement of a recognised authority is read and considered in connection with the present position regarding foul-brood, it will convince all but the most prejudiced of the accuracy of the author's contention.

Surplus Gathering

Viewing the subject from a different angle, we find further evidence supporting us. The present world's record—so-called—for surplus honey is held by a bee-keeper in the U.S.A. It was gained by a stock of Caucasians. But the

special preparation of this stock must be noted, since there is no record of any other stock having been similarly prepared. This stock was divided into three, the two queenless portions made to rear their own queens and the total surplus gathered by the three stocks was added together as the product of one!

We now turn to Doolittle's *Queen Rearing*, from which we extract the following. ". . . Look at that colony," he writes, "you had one spring which gave you 100, 200, 400, 600, or even 1,000 pounds of honey (one or two reports of nearly 1,000 pounds of honey from a single colony have been given in the past, while the reports of those giving from 400 to 600 are numerous), and say why it did so well. . . ."

Assuming the accuracy of those figures in the above extract from Doolittle, to what extent have we improved on those returns?

We are further told that Quimby knew of 500 pounds of surplus honey being taken from a single hive, and that at a period many years before Doolittle invented his system of transferring larvae, and before the superfecund queen was even imagined. At the period when the above amounts of surplus honey were taken, equipment, manipulation and bee-fodder were much

behind what they are at the present day. Yet, although these have advanced, we have not excelled those returns of honey.

In view of the foregoing, and because present-day methods of bee-breeding do not take advantage of the knowledge gained by the breeding of other live-stock, we submit that there is an urgent necessity for a change in bee-breeding methods, providing the new methods are in accordance with well-tested facts and natural laws. The breeding methods advocated in this book are strictly in accordance with such laws, which, however, operate with the bee in a manner peculiar to the insect, which is the only domestic animal that is subject to parthenogenesis. It is because of the latter that the laws vary with the bee.

THE END

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